A NEW CLASSIFICATION OF THE OPHIUROIDEA: WITH DESCRIPTIONS OF NEW GENERA AND SPECIES.

BY H. MATSUMOTO.

Contents.

Introduction.

The present study was undertaken at the suggestion of Prof. Goto, of the Imperial University of Tokyo; and to him my hearty thanks are due for supervision and the revision of part of the manuscript.

My first purpose was merely to identify and name species. But

I soon found that the classifications of the Ophiuroidea hitherto proposed were very unsatisfactory. Indeed, their imperfectness became a haunt to me; so I determined to devise a new classification of my own.

For this purpose, I have dissected representatives of as many genera as were accessible; and the following are some of the more important results obtained:

A. *Morphological.*—Those forms that have arms, capable of being vertically coiled, have a very compact oral skeleton (the adoral shields are entirely proximal to the oral shield, being firmly united to it; the oral frames are very stout, those of the same radius being firmly joined together; the peristomal plates are entire and more or less soldered to the oral frames, etc.), and very short, stout vertebræ, of which the articulation is streptospondyline, with a very rudimentary, or no articular peg. More or less divided vertebræ are found only in certain genera with horizontally flexible arms; such vertebræ are of two kinds, those which are divided into halves by a single fusiform pore (found in forms in which the dorsal side of the arms is more or less unprotected) and those in which the two halves are separated by a series of small pores (found in forms with the dorsal side of the arms entirely protected). Forms with quadrangular and stout teeth have oral frames with well-developed lateral wings for the attachment of voluminous masticatory muscles, etc.

B. *Systematic.*—*Astroceras*, *Trichaster* and *Euryala* have a certain common structure, by which they may be distinguished from either *Asteronyx* or *Asteroschema; Astrotoma* and its allies have certain distinctive characters in contrast to *Asteroporpa, Astrochele, Gorgonocephalus, Astrocladus* and their allies; the Amphiuridæ (emend.) and the Ophiotrichidæ are intimately related by their internal structure; "*Ophiactis*" pars, *i.e.*, my *Amphiactis*, is a connecting link between the Ophiacanthidæ and Amphiuridæ; the Ophiolepididæ, Ophiodermatidæ and Ophiocomidæ form together another compact group; my Ophiochitonidæ are not referable to Amphiuridæ (emend.) but are very near the Ophiodermatidæ and Ophiocomidæ; *Ophiopsila* is, as a matter of fact, a near ally of the Ophiocomidæ; "*Ophioconis*" pars, *i.e.*, my *Ophiuroconis* and *Ophiurodon*, and "*Ophiochæta*" pars, *i.e.*, my *Ophiurochæta*, are perfectly distinguishable from *Ophiolimna* (emend.), by their internal structure, etc.

Prefixing so much, I now proceed to the exposition of my views, leaving them to be judged on their merits.

During the present study, I have received great help from Dr. Hubert Lyman Clark, of the Museum of Comparative Zoölogy, in the loan of many precisely determined specimens from that Museum and in helpful advice; my best thanks are due to him. This paper is in fact an outcome of his suggestions. A more detailed monograph with illustrations will be published ultimately in Japan.

The outbreak of the present war has made it impossible for me to receive some specimens of Palæozoic ophiurans promised me by Dr. B. Stürtz, so that I am obliged to defer a revision and classification of Palæozoic ophiurans to the future.

The greater part of the present study was done in the Zoölogical Institute of the Imperial University of Tokyo, and the type specimens of all the new species described belong to it.

Sendai, Japan, December 1, 1914.

Subclass I. ŒGOPHIUROIDA nov.

Ophiuroidea with external ambulacral grooves, and without ventral arm plates. Radial shields, genital plates and scales, oral shields and dorsal arm plates also absent. Ambulacral plates alternate or opposite; in the latter case, they may often be soldered in pairs to form the vertebræ. Adambulacral plates, *i.e.*, lateral arm plates, subventral. Madreporite either dorsal or ventral, often large and similar in shape to that of an Asteroid.

This subclass consists chiefly of Palæozoic genera.

The Œgophiuroida lack all the fundamental characters by which Recent ophiurans are clearly distinguished from Asteroids. Indeed, the distinction of the present subclass from the cryptozonial Asteroids depends merely upon the different development of certain common structures.

Subclass II. MYOPHIUROIDA nov.

Ophiuroidea without external ambulacral grooves, and with ventral arm plates. Radial shields, genital plates and scales, oral shields and dorsal arm plates usually present; but sometimes rudimentary or absent. Ambulacral plates opposite, usually completely soldered in pairs to form the vertebræ. Madreporite represented by one, or sometimes all, of the oral shields.

This subclass includes certain Palæozoic forms and all the ophiurans since the Mesozoic.

Order I. PHRYNOPHIURIDA nov.

Disk and arms covered by a skin. The radial shield and genital plate articulate by means of a simple face or a transverse ridge on either plate, without well-developed articular condyles and sockets. Peristomal plates large, entire, or sometimes double or triple. Oral frames entire, without well-developed lateral wings. Dorsal arm plates absent or very rudimentary; lateral arm plates ventral or subventral in position; dorsal side of arms largely unprotected.

Key to families of Phrynophiurida.

A—Lateral arm plates more or less subventral; arm spines not confined to ventral side of arm, but lateral or subventral in position; vertebræ not very short and stout, with not exceedingly stout wings; upper and lower muscular fossæ of vertebræ rather subequal; radial shields small or rudimentary, OPHIOMYXIDÆ.

AA—Lateral arm plates and arm spines confined to the ventral side of the arm; vertebræ very short and stout, discoidal, with exceedingly stout wings; upper muscular fossæ of vertebræ extremely large, lower very small; vertebral articulation typically streptospondyline; radial shields long and bar-like.

a—Arms without rows of hook-bearing granules; arm spines covered by thick skin; adoral shields very stout, TRICHASTERIDÆ.

aa—Arms annulated by double rows of hook-bearing granules; arm spines naked, or at most covered by thin skin; adoral shields rather small and inconspicuous, often separated from oral shields by small supplementary plates, GORGONOCEPHALIDÆ.

Family 1. OPHIOMYXIDÆ Ljungman, 1866.

(Characters as given above in key.)

Key to subfamilies of Ophiomyxidæ.

A—Oral shields separated from first lateral arm plates by outer lobes of the adoral shields; peristomal plates usually double or triple, not very thick, not firmly fixed to the oral frames, which are rather slender; vertebræ long and slender, except one or two basal ones which are discoidal, distal ones usually divided into halves; wings of vertebræ not equally thick, but distinctly much thinner laterally than dorsally; vertebral articulation zygospondyline, the articular peg being well developed ..... OPHIOMYXINÆ.

AA—Oral shields in contact with first lateral arm plates; adoral shields entirely proximal to oral shield; peristomal plates

entire, very thick, fused with oral frames, which are very stout; vertebræ rather short and very stout, many proximal ones discoidal, none divided into halves; wings of vertebræ almost equally thick laterally and dorsally; vertebral articulations streptospondyline; articular peg very rudimentary, or absent.....OPHIOBYRSINÆ.

Subfamily 1. OPHIOMYXINÆ Ljungman, 1871 (emend.).

(Characters as given above in key.)

This subfamily includes *Ophiohelus*, *Ophiosciasma*, *Ophiogeron*, *Astrogeron*, *Ophiocynodus*, *Ophiostyracium*, *Ophiosyzygus*, *Ophioleptoplax*, *Ophioscolex*, *Neoplax*, *Ophiomora*, *Ophiomyxa*, *Ophiodera*, *Ophiohymen*, and provisionally *Ophiambix*, besides two new genera, *Ophiostiba* and *Ophiohyalus*.

OPHIOSTIBA gen. nov.

Disk covered by a skin containing a number of scattered granules. Radial shields very rudimentary, forming a continuous row with the marginal disk scales, which are well developed, as in *Ophiomyxa*, *Ophiomora* and *Neoplax*. Teeth and oral papillæ present, with acute ends. Arms skin-covered; dorsal arm plates absent, while the lateral arm plates are subventral, so that the dorsal side of the arms is largely naked. Distal vertebræ more or less divided into halves by a longitudinally fusiform pore. Arm spines few, all converted into compound hooks. Tentacle scales absent.

This new genus differs from *Ophioscolex* chiefly in the presence of the marginal disk scales and in the conversion of the arm spines into compound hooks; and from *Neoplax* in the fewer arm spines, which are converted into compound hooks, and in the absence of tentacle scales.

Ophiostiba hidekii[1] sp. nov.

Diameter of disk 3.5 mm. Length of arms 16 mm. Width of arms at base 0.8 mm. Disk hexagonal, with concave interradial borders, covered by a soft skin, which contains a number of scattered granules. Radial shields very rudimentary and insignificant, forming a continuous row with the marginal disk scales, which are well developed. Genital slits very small and short.

Oral shields rhomboidal, with perfectly rounded outer and lateral angles, convex, slightly longer than wide; each serving as a madre-

[1] Dedicated to the memory of my friend, Hideki Chiba, who met with an untimely death a few days after assisting me in dredging my material in the Sagami Sea.

porite. Adoral shields long and narrow, but with widened outer ends, meeting each other within. Four or five oral papillæ on either side, triangular, with acute apices. Teeth stout, triangular, acute.

Six arms, of which three are longer than the other three, as an indication of schizogony. Dorsal arm plates entirely absent; dorsal side of vertebræ clearly visible. Lateral arm plates low, meeting below. First ventral arm plates very small, rhomboidal, longer than wide; the following heptagonal, with strongly concave proximo-lateral and outer sides (the former adjoining the tentacle pores), much longer than wide, widest opposite the outer ends of the tentacle pores; calcification very feeble along median line, the plates appearing as if longitudinally grooved. In the outer half of the arm, the vertebræ are more or less divided into halves by fusiform pores. Two or three hyaline arm spines, converted into compound hooks, with four or five denticles along the abradial side; the lowest one is slightly shorter than the upper ones, which are about two-thirds as long as the corresponding arm joint. The uppermost spines of either side of successive arm joints are connected by a hyaline, web-like membrane, except on the basal and most distal joints. Tentacle pores large, without any scale. Color in alcohol: disk deep chocolate-brown, except the granules, which are white; arms brownish yellow.

Two specimens; Sagami Sea; 300 fathoms.

This new species evidently reproduces by schizogony, as indicated by the hetaractiny and the occurrence of six madreporites.

OPHIOHYALUS gen. nov.

Disk covered by a skin, with marginal scales. Radial shields very rudimentary, forming a continuous row with the marginal disk scales. Teeth and oral papillæ flattened and serrate, like those of *Ophiomyxa*, *Ophiodera* and *Ophiohymen*. Dorsal arm plates present, but rudimentary, entire, thin, hyaline, separated from each other by naked spaces. Vertebræ more or less divided into halves. Arm spines few, converted into compound hooks. Tentacle scales absent.

This new genus is near *Ophiomyxa*, but differs from it in the rudimentary radial shields, the divided vertebræ, the entire rudimentary dorsal arm plates and the conversion of the arm spines into compound hooks. In almost all characters, *Ophiohyalus* is more embryonal than *Ophiomyxa*.

Ophiohyalus gotoi sp. nov.

Diameter of disk 9 mm. Length of arms 28 mm. Width of arms at base 1 mm. Disk pentagonal, with concave interradial borders, very flat, covered by a thin skin. Marginal disk scales present, feeble. Radial shields rudimentary and insignificant, forming a continuous row with the marginal disk scales. Genital slits small and short, extending from outer end of adoral shield to that of second lateral arm plate.

Oral shields triangular, with perfectly rounded lateral angles, outer side slightly concave; two and a half times as wide as long. Adoral shields large, triangular, very long, acutely tapered inwards, but not meeting. Oral plates long and narrow. The space encircled by the oral and adoral shields and oral plates is strongly depressed. Three or four oral papillæ on either side, thin, hyaline, serrate along the free edge. Two or three short, wide, flattened teeth, with rounded and finely serrate ends. Deep in the oral slit on either side of each jaw there occurs one conical, rough papilla, which protects the first oral tentacle pore.

Arms slender, covered by a very thin, transparent skin. Dorsal arm plates small, oval, thin, hyaline, longer than wide, wider within than without, separated from each other by naked spaces; they lie over the distal parts of the vertebræ of the corresponding arm joints, and become very small and delicate towards the extremity of the arm. Lateral arm plates low, slightly flaring, successive plates not in contact with each other, but separated by a naked space, which is widened upwards and continued into a large naked space bounded by the dorsal and lateral arm plates and the vertebra. First ventral arm plate not very small, quadrangular, with strongly curved outer side, much wider without than within; those beyond nearly rhomboidal in outline, with a conspicuous reëntrant notch at outer end and a half pore for the tentacle at each lateral angle; much longer than wide, widest opposite outer ends of tentacle pores; successive plates not in contact with each other, except within the disk. The lateral arm plates do not, however, meet each other in the ventral median line, so that there is left here a naked, depressed space, which is especially well-marked near the extremity of the arm. Except within the disk and at the very base of arms, the vertebræ are more or less or entirely divided into halves by fusiform pores, which become larger and longer in the more distal part of the arm. Arm spines two, subventral, unequal, glassy, all converted into compound hooks, with a series of hooklets along their ventral side, covered by

a thin, transparent skin; the lower one is much larger and longer than the upper. On some basal arm joints there occurs on the lateral arm plate one more spine, which is placed on the dorsal margin of the plate and also bears a series of hooklets on one side; it is larger and longer than the other two and nearly as long as the corresponding arm joint. No tentacle scale. Color in alcohol: yellowish white.

Two specimens; probably Sagami Sea.

Subfamily 2. OPHIOBYRSINÆ nov.

(Characters as given in key, p. 46.)

This subfamily includes *Ophiobyrsa*, *Ophiobyrsella*, *Ophiophrixus*, *Ophiobrachion* and provisionally *Ophioschiza*, besides a new genus, *Ophiosmilax*.

The Ophiobyrsinæ rather approach the next two families in skeletal characters.

OPHIOSMILAX gen. nov.

Disk and arms covered by a thick skin. Radial shields very rudimentary and insignificant. Single oral papilla on either side and two or three dental papillæ at the apex of each jaw. Teeth in a single vertical series. Teeth and papillæ all alike, stout, stumpy, conspicuously thorny at tips. Second oral tentacle pores open outside oral slits, each provided with a thorny, stumpy papilla, which arises from adoral shield. Dorsal arm plates absent, while the lateral arm plates are subventral, so that the dorsal side of the arms is merely covered by a naked skin. Ventral arm plates well-developed, in contact with each other. Vertebræ short and very stout. Vertebral articulation streptospondyline, the articular peg being entirely absent. Arm spines few, converted into compound hooks. No tentacle scale.

This new genus more or less resembles *Ophiophrixus* in the total absence of dorsal arm plates, but differs from it in the rudimentary radial shields, in the peculiarities of teeth and papillæ and in the conversion of arm spines into compound hooks. The last character reminds us of *Ophiobrachion*, but Ophiosmilax has no disk spines, while it does have peculiar teeth and papillæ and fewer and longer arm spines.

Ophiosmilax mirabilis sp. nov.

Diameter of disk 2 mm. Length of arms 12 mm. Width of arms 0.8 mm. Disk pentagonal, with concave interbrachial borders, covered by a thick skin, which contains very fine, thin, transparent

scales. Radial shields rudimentary and insignificant, lying on the disk margin. Genital slits very small and short.

Oral shields triangular, with convex outer border. Adoral shields large, quadrangular, meeting within. Oral slits short, fairly closed up. Single oral papilla on either side, short, stumpy, conspicuously thorny at tip, turned up ventrally, instead of projecting towards oral slit. Two or three dental papillæ at apex of each jaw, similar in shape and in size to oral papilla, also turned up ventrally. Teeth in a single vertical series, stout, stumpy, thorny at tips. Second oral tentacle pores open outside oral slits, each provided with a stumpy and thorny papilla, which arises from adoral shield.

Arms stout in comparison with the small disk, covered by a thick, naked skin. Dorsal arm plates absent. Lateral arm plates subventral, strongly flaring. First ventral arm plate large, quadrangular, with rounded angles, slightly longer than wide, much wider without than within; those beyond also large, hexagonal; proximal and proximo-lateral sides very short; distal and disto-lateral sides long; outer angles perfectly rounded; as long as, or slightly longer than, wide, feebly calcified and transparent, except the outer and lateral margins, where the calcification is complete and opaque. Vertebræ short and very stout, with streptospondyline articulation, the articular shoulder and umbo being very stout, while the articular peg is entirely absent. Arm spines two or three, lying flat on the arm, all converted into compound hooks, hyaline; the uppermost two are subequal, about two-thirds as long as corresponding arm joint, while the lowest one is about half as long as the same. The smaller spines have two or three hooklets, which lie in one plane, while the larger ones have six or seven hooklets, which lie in two divergent planes. Tentacle pores small, without scales. Color in alcohol: brownish yellow.

One specimen; Sagami Sea; 300 fathoms.

Family 2. **TRICHASTERIDÆ** Döderlein, 1911 (emend.).

(Characters as given in key, p. 46.)

Key to subfamilies of Trichasteridæ.

A—More than three arm spines; madreporite single, ASTERONYCHINÆ.

AA—Two arm spines; all oral shields serving as madreporites.

a—Lateral arm plates of opposite sides separated from each other by the ventral arm plates, distal ones projecting ventrally like hanging rods; arm spines subequal; peri-

hæmal canal and genital bursæ communicating with each other.....TRICHASTERINÆ.

aa—Lateral arm plates of opposite sides meeting each other in the ventral median line, distal ones not projecting ventrally like hanging rods; arm spines unequal, the adradial one being much larger and longer than the abradial and often clavate; perihæmal canal and genital bursæ not in communication; arms simple.....ASTEROSCHEMATINÆ.

Subfamily 1. ASTERONYCHINÆ nov.

Disk very large, arms very slender and unbranched. A single madreporite is present. Perihæmal canal entirely closed. Peritoneal cavity divided into five compartments by the interradial attachments of the gastral pouches to body wall. Genital bursæ separated from the perihæmal canal and the peritoneal cavity, but the pairs of the same radius communicating with each other, the communication passing above the outer end of the oral frames and the first vertebra, just outside the perihæmal canal. Lateral arm plates of opposite sides separated by the comparatively large ventral arm plates. Arm spines, 3–8.

This subfamily includes *Asteronyx* and *Astrodia*.

Subfamily 2. TRICHASTERINÆ nov.

(Characters as given above in key.)

This subfamily includes *Ophiuropsis*, *Astroceras*, *Trichaster*, *Sthenocephalus* and *Euryala*.

Subfamily 3. ASTEROSCHEMATINÆ Döderlein, 1911 (emend.).

(Characters as given above in key.)

This subfamily includes *Asteroschema* (including *Ophiocreas*) and *Astrocharis*.

Asteroschema tubiferum Matsumoto.

1911, Dobuts. Z. Tokyo, **23**, p. 617 (in Japanese).

This species strongly resembles *A. rubrum* Lyman, but differs chiefly in the much coarser granules of the arm bases, in having tentacle tubes for some ten basal tentacles, and in the relatively longer and stouter arm spines. Three or four granules lie in 1 mm. on the dorsal side of the free arm base. Oral tentacle pores, as well as tentacle pores of some ten basal arm joints, open by means of cuticular tubes, each of which, except that of the oral tentacle and the first arm tentacle, is attached to the adradial arm spine on its adradial side. The arm spines become longer and stouter distally,

till the adradial one is distinctly clavate and is about twice as long as the corresponding arm joint. The color is light pinkish brown in alcohol. The type specimen is 16 mm. in disk diameter, 230 mm. in arm length and 4.5 mm. in arm width at base.

Two specimens; Okinosé (a submarine bank), Sagami Sea. One specimen; Sagami Sea.

Asteroschema glaucum Matsumoto.

1911, Dobuts. Z. Tokyo, **23**, p. 617 (in Japanese).

This species is near *A. salix* Lyman, but differs from it in coarser granules on disk and arm bases, in stouter arm bases, in much shorter arm spines, and in oral tentacles being enclosed in tubes. About six granules lie in 1 mm. on the radial ribs and free arm bases. Arms very stout at base, as high as wide. Arm spines longer and stouter outwards, till the adradial one is somewhat clavate and is slightly longer than the corresponding arm joint. Oral tentacles enclosed in tubes. First two or three tentacle pores also provided with tubes, though rudimentary. The color is pale gray in alcohol. The type specimen is 11 mm. in disk diameter, 100 mm. in arm length and 4 mm. in arm width at base.

Three specimens; Sagami Sea; 110 fathoms.

Asteroschema hemigymnum Matsumoto.

1912, Dobuts. Z. Tokyo, **24**, p. 381 (in Japanese); figs. 3, 4.

Diameter of disk 10 mm. Length of arms 120 mm. Width of arms at base 3 mm. Disk rather flat, divided into ten lobes, corresponding to the radial ribs, by ten radiating furrows; covered by a skin, which contains very fine, smooth, close-set granules. Ventral interbrachial areas rather vertical, narrow, forming a deep notch, on the floor of which opens one madreporic pore. Genital slits rather short, more or less divergent dorsally. Ventral surface of disk covered by a finely and rather sparsely granulated skin.

Oral angles not markedly set off from the outer parts. Six or seven teeth arranged in a single vertical row, triangular, very stout. On either side of the oral angles, there are several coarse, flat, smooth, pavement-like grains, which correspond to oral papillæ.

Arms very stout for the first three or four free joints, but becoming rather slender further out; their width just outside the fourth free joint is 2.5 mm. They constantly taper outwards, so that they are exceedingly slender towards the extremities, which are very acute. Dorsal and lateral surface of the arms covered by a skin, which is similar to that of the disk, containing very fine, smooth, close-set

granules, of which there are about five in 1 mm. on the dorsal surface of the arm bases. The granules become much finer outwards, and almost disappear near extremity of arm. Vertebræ visible through skin, but surface of arm practically smooth and without distinct demarcation of joints, except of first three or four, which are marked off by shallow constrictions. Ventral surface of arms entirely naked, and lateral and ventral arm plates clearly visible through skin. First tentacle pore unprotected; next four or five pores provided with a single arm spine, and the rest with two. Abradial spine very small, cylindrical, enclosed in skin, more or less rough at free end. Adradial one clavate, enclosed in skin, very rough at free end. Arm spines largest at middle of arm, the adradial one being one and a half times as long as, and the abradial one a little shorter than, the corresponding arm joint. They are transformed into compound hooks, with three to six hooklets, towards the very extremity of the arm. Oral tentacle pore and first three or four tentacle pores provided with tubes. Color in alcohol: grayish brown.

One specimen; Sagami Sea.

Like *A. intectum* Lyman and *A. migrator* Koehler, this species appears to be an intermediate form between the sections *Asteroschema*, s. str., and *Ophiocreas*.

Astrocharis ijimai Matsumoto.

1911, Dobuts. Z. Tokyo, **23**, p. 617 (in Japanese).

Diameter of disk 4.5 mm. Length of arms 50 mm. Width of arms at base 2.5 mm. Disk five-lobed, with deeply indented interbrachial borders, with lobes emarginate towards arms, flat, sunken at the central region, raised at the lobes, covered with very fine, smooth, irregular scales, which are very close-set and partly imbricated. Radial shields naked, very small, triangular, with apex turned within, tuberculous when examined under a microscope. Ventral interbrachial areas with very deep notches, exceedingly narrowed by the very wide arm bases. Two genital slits small, parallel, nearly vertical. On either side of each lobe of the disk, lies the naked genital plate, which is large, oval, and tuberculous under a microscope.

Oral angles puffed laterally, almost filling up the oral slits. Teeth small, triangular, arranged in a single vertical row. No oral or dental papillæ.

Arms very wide at base, keeping the same width for a distance of about 4 or 5 mm., then rather rapidly narrowed, becoming slender and cylindrical, with a width of about 1 mm.; covered with fine

scales similar to those of the disk. Arm joints invisible in the proximal part of the arm, but more or less distinct distally. First tentacle pore free of arm spines; those beyond provided with a single spine, which is very small, short, peg-like, somewhat flattened, rough at the end as seen under a microscope, lying flat on the ventral surface of the arm. Half way out on the arm, each tentacle pore is provided with two spines, of which the second, or abradial one, is exceedingly small and rather inconspicuous; the adradial one then becomes a little longer and erect to the arm. Color in alcohol: white or pale yellow.

Numerous specimens; Sagami Sea.

In smaller specimens, the arms are scarcely widened at the base, which is also the case in regenerating ones; for schizogony takes place in this species as in the genotype, *A. virgo* Koehler. Most specimens are five-armed, but the arms are often unequal, two or three being larger than the others. I have, however, one specimen with six arms, three larger and three smaller. In four-armed specimens, two or three arms may be larger and the other two or one smaller. Still another specimen has only three arms, doubtless indicating that it has lately undergone division, and that the lost parts have not been regenerated.

Family 3. **GORGONOCEPHALIDÆ** Döderlein, 1911.

(Characters as given in key, p. 46.)

Key to subfamilies of Gorgonocephalidæ (I).

A—Teeth, dental papillæ and oral papillæ all similar, spiniform; oral angles not strongly projected ventrally; genital slits small, often pore-like, lying near the disk border; basal vertebræ not very small, not covered over by the muscles between the basal vertebræ and genital plates,
GORGONOCEPHALINÆ.

AA—Teeth and dental papillæ similar, spiniform; oral papillæ absent or, at least, extremely reduced; genital slits large, extending nearly from the inner corners of the interbrachial ventral surfaces to the disk margin; basal vertebræ very small, covered over by the muscles, which connect the basal vertebræ and genital plates.....ASTROTOMINÆ.

Key to subfamilies of Gorgonocephalidæ (II).

A—Arms simple or branched a few times.

a—Teeth, dental papillæ and oral papillæ all well developed; oral and adoral shields in direct contact with each other, without supplementary plates in the oral region,
GORGONOCEPHALINÆ, pars.

aa—Teeth and dental papillæ well developed, but oral papillæ absent or very rudimentary; oral and adoral shields separated from each other by a mosaic of supplementary plates.....ASTROTOMINÆ.

AA—Arms branched many times; teeth, dental papillæ and oral papillæ all well developed; oral and adoral shields separated from each other by a mosaic of supplementary plates, GORGONOCEPHALINÆ, pars.

Subfamily 1. GORGONOCEPHALINÆ Döderlein, 1911 (emend.).

(Characters as given above in keys.)

This subfamily includes *Astrogomphus*, *Astrochele*, *Astrochlamys*, *Asteroporpa*, *Astrocnida*, *Conocladus*, *Astroconus*, *Gorgonocephalus*, *Astrodendrum*, *Astrocladus*, *Astrospartus*, *Astroboa*, *Astrophytum*, *Ophiocrene*, *Astrochalcis*, *Astrogordius*, *Astrocyclus*, *Astrocaneum* and *Astrodactylus*.

Astrocladus annulatus (Matsumoto).

Astrophyton annulatum, 1912. Dobuts. Z. Tokyo, **24**, p. 206 (in Japanese); figs. 17, 18.
Astrocladus annulatus, 1912. Dobuts. Z. Tokyo, **24**, p. 389.

Diameter of disk, 22 mm. Distance from centre of disk to interradial margin, 8.5 mm. Distance from outer end of oral slit to first bifurcation of arm, 11 mm. Arms branched nineteen or twenty times, measuring about 125 mm. in total length. Width of ventral side of arm base within disk, 4.5 mm. Disk five-lobed, with concave interbrachial borders, covered by a thick skin, which is apparently smooth, but contains fine, close-set granules of microscopic size. On the radial ribs these granules are flattened, pavement-like and coarser, being even visible to the naked eye. Several smooth, hemispherical tubercles are scattered on the disk. Radial ribs gently raised, forming rounded ridges, with rather indistinct outlines, not quite reaching to the disk centre; their back is marked with concentrically arranged swellings, corresponding to the imbricating, soldered plates, of which the radial shield is composed. The ventral surface of the disk appears smooth to the naked eye. Genital slits not very large.

Madreporic shield single, at inner corner of a ventral interbrachial area, small, transversely oval. Teeth and dental papillæ, conical and rather stout. Oral papillæ and lower dental papillæ, smaller and very short.

Arms slender and branched, with distinction of trunk and lateral branch even at the base; covered on dorsal side by a finely and closely

granulated skin, with several scattered, smooth, hemispherical tubercles on the more proximal shafts; distinctly annulated with hook-bearing segments throughout. Ventral surface of arms entirely smooth. Arm spines, which are present beyond first bifurcation, very fine and three or four in number at each tentacle pore. Color in alcohol: disk mottled and arms annulated with yellowish and grayish brown.

One specimen; Sagami Sea.

This species can be easily distinguished from other species of *Astrocladus* by the entirely smooth disk covering and by the arms, which are distinctly annulated with hook-bearing segments even at the very base.

Astroboa arctos sp. nov.

Diameter of disk, 65 mm. Distance from centre of disk to interradial margin, 25 mm. Distance from outer end of oral slit to first bifurcation, 32 mm. Arms branched about thirty-seven times, measuring approximately 420 mm. in total length. Width of ventral surface of arm base within disk, 17 mm.

Disk decagonal, with concave interbrachial and brachial borders, the former being longer and more concave than the latter; very high and convex, but with more or less depressed central region, covered by a thick skin, which is shagreened by the presence of very fine, close-set granules. The granules are smooth, not acute, irregular in size, when viewed under a microscope, the coarser ones being more numerous on the radial ribs than in the intercostal spaces. Radial ribs long, narrow, bar-like, widest at outer end, suddenly narrowed for a very short distance, then uniformly tapered inwards, nearly reaching disk-centre. Ventral interbrachial areas covered by thick, apparently smooth skin, which, however, contains fine, microscopical granules. Genital slits rather large, adradial border protected by a cluster of close-set spinules.

Madreporic shield, situated at inner angle of a ventral interbrachial area, more or less semilunar, with semicircular inner, and distinctly notched outer, side and rounded lateral angles. Areas proximal to ventral interbrachial regions, apparently smooth, but closely covered with very fine granules of microscopic size, the granules being rather coarse and distinct at the oral angles. Teeth and papillæ very numerous; oral and dental papillæ, rather small, spiniform, and not very acute; teeth, much larger and longer than papillæ, distinctly spatulated, and flattened at tip.

Two main stems, outside the first bifurcation, of an arm are not

equally developed, but one is longer, stouter and more branched than the other. Dorsal and lateral surface of arms covered by a thick skin, which is very finely and closely granulated; granules, irregular in size and roughly distinguished as of two kinds; finer ones entirely covered by skin, flat, irregularly polygonal, forming together a sort of mosaic; coarser ones, coarser than any granules of disk, hemispherical, tubercle-like, and uniformly scattered. Ventral surface of arms apparently smooth, but covered by a mosaic of flat and irregularly polygonal granules of microscopic size. First pair of tentacle pores distinct, opening in slight depressions; second often distinct; following three or four pairs entirely invisible; those beyond are again distinct. Arm spines absent on proximal joints, but occur from fourth or fifth bifurcation outwards. They are exceedingly minute and granule-like, two to four of them occurring at each tentacle pore. The double rows of hook-bearing granules are present only on very fine twigs, the main stems within fourteenth or fifteenth bifurcation being free from them. The shaft between the first and second bifurcations usually consists of four arm joints; the outer shafts consist of six to eight, usually seven joints. Color in alcohol, as well as when dry: dark grayish brown above, and dark yellowish brown below.

Two specimens; off Misaki Marine Biological Station; 5–10 fathoms. Four specimens; Sagami Sea.

Among the five known species of *Astroboa*, *A. clavata* (Lyman) is distinguished from the others by the spiny granules of the disk and arms, and *A. globifera* (Döderlein) by the position of the madreporic shield. *A. nuda* (Lyman) and *A. nigra* Döderlein have distinct annulations of hook-bearing granules on the arms throughout, while *A. ernæ* Döderlein has no such annulations on the greater proximal part of the arms. So that the present species is near *A. ernæ*, but differs from it in the much finer and less distinct granules of the disk and arms, and in the less numerous arm joints composing a shaft. In the last character, *A. arctos* rather resembles *A. nigra* from Zanzibar and from Hirado Strait.

This species is common in the shallow waters around Misaki, occurring together with *Astrocladus coniferus*, especially var. *dofleini* [*A. dofleini* Döderlein is, in my opinion, conspecific with *A. coniferus* (Döderlein), being, however, a variety of the latter]. According to present knowledge, *Astroboa* is represented in the Sagami Sea by *A. globifera* and the present species, in deep and shallow water respectively.

Subfamily 2. ASTROTOMINÆ nov.

(Characters as given in keys, p. 55.)

This subfamily includes *Astrothrombus*, *Astrothorax*, *Astrotoma* and *Astroclon*, besides a new genus, *Astrothamnus*.

Astrothamnus gen. nov.

Disk divided into ten radiating lobes by radial and interradial furrows, closely covered with coarse granules or stumpy tubercles, which are acute or thorny at tips. Ventral interradial areas strongly concave, with large, long, more or less parallel genital slits. Teeth and dental papillæ similar, spiniform, forming a cluster at the apex of each jaw. Oral papillæ absent, so that the sides of the oral slits are naked. Arms simple, distinctly annulated by zones of densely set, minute, compound hooks; the interannuli are covered with coarse granules, which are arranged more or less clearly in two series. Arm spines 3–5, peg-like, usually rough at tips, serving as tentacle scales.

This genus includes Koehler's *Astrotoma bellator*, *A. vecors* and *A. rigens*, besides the genotype, *Astrothamnus echinaceus* sp. nov.

Astrothamnus is distinguished from genuine *Astrotoma* as follows:

A—Disk covered with coarse granules or stumpy tubercles, which are acute or thorny at tip; arms annulated by conspicuous zones of densely set compound hooks; interannuli of arms covered with coarse granules, which are arranged more or less clearly in two series ..... *Astrothamnus*.

AA—Disk covered with very fine, smooth granules, often beset with a number of smooth, stumpy tubercles; arms rather inconspicuously annulated, each annulus consisting of four rows of granules, the middle two hook-bearing, while the others are smooth; interannuli covered by a pavement of very fine granules, among which many oval, sunken plates are present ..... *Astrotoma*, restr.

In the arm coverings, *Astrothamnus* is similar to *Astrothrombus* and *Astrothorax*, while *Astrotoma*, restr., resembles *Astroclon*. Thus the Astrotominæ fall naturally into two groups, one of which includes the first three genera, and the other the last two.

Astrothamnus echinaceus (Matsumoto).

Astrotoma echinacea, 1912. Dobuts. Z. Tokyo, **24**, p. 200 (in Japanese); figs. 6–8.

Diameter of disk, 22 mm. Length of arms, 140 mm. Width of arms at base, 4 mm. Disk distinctly five-lobed by five interradial furrows, each lobe being again divided into two secondary lobes by

the radial furrow. Radial ribs much raised, large, occupying almost the whole dorsal surface of disk, but leaving between them ten narrow furrows radiating from the centre; closely covered with rather large stumpy tubercles with thorny crowns, between which lie thick, irregularly polygonal plates. Ventral interbrachial areas strongly concave, closely covered with stumpy tubercles terminating with one or a few thorny points. Genital slits rather large, more or less parallel.

Madreporic shield small, irregular in outline. Areas proximal to ventral interbrachial regions closely covered with spiny, stumpy tubercles. Oral angles ventrally projected, covered with conical and acute tubercles, which become, near mouth, more or less indistinguishable from dental papillæ. Teeth and dental papillæ similar, conical, very acute. Oral papillæ absent; sides of oral angles naked.

Arms rather slender, long, uniformly tapered outwards, distinctly annulated by double rows of coarse granules, which are entirely covered with densely set, minute, compound hooks; interannuli covered with coarse, smooth granules arranged in two irregular rows. Ventro-laterally on either side of arm, in line with interannuli, there is a series of large, round, smooth plates. At the arm bases, the hook-covered annuli are usually broken in the dorsal median line by conical granules terminating with one or a few thorny points. Ventral side of arms with rather well-spaced tubercles, which are conical or terminate with one or a few thorny points; these tubercles become rounded and smooth distally. First and second tentacle pores free of arm spines; third with one or two spines; fourth with two or three; remainder with three. Arm spines of basal joints more or less indistinguishable from conical or thorned tubercles, but remainder peg-like, nearly as long as corresponding arm joint, and bearing two or three denticles at tip. Oral tentacle pores, as well as first and second arm tentacle pores, open by means of short tubes, which bear a few spinules on the sides. Color in alcohol: dull grayish purple.

Two specimens, Sagami Sea.

In Koehler's species, *vecors* and *rigens*, the brachial ventral surfaces are smooth and the oral angles, as well as the spaces just proximal to the ventral interbrachial areas, are provided with slender spines, while in *A. bellator* (Koehler), as well as in the present species, the brachial ventral surfaces, oral angles and the oral spaces referred to are provided with coarse, stumpy granules or tubercles. The present species, however, differs from *A. bellator* in fewer and distinctly longer

arm spines and in the presence of a series of large plates on either side of each arm.

Astrotoma Lyman (non Koehler).

As I have referred Koehler's three species, which he placed in Astrotoma, to Astrothamnus, Astrotoma, restr., now includes *A. agassizi* Lyman, *A. murrayi* Lyman, *A. sobrina* Matsumoto, and *A. waitei* Benham, the first being the genotype.

Astrotoma sobrina Matsumoto.

1912, Dobuts. Z. Tokyo, **24**, p. 199 (in Japanese).
Astrotoma murrayi Döderlein (non Lyman, 1879), Abh. Math.-Phys. Kl. K. Bayer. Akad. Wiss., Suppl.-Bd. I, 1911, p. 23, fig. 1, Pl. VI, figs. 1 and 1*a*, Pl. VII, figs. 14–14*b*.

Though the present Japanese form was identified as *A. murrayi* by Döderlein, I have failed to find any specimen from Japan that strictly corresponds to Lyman's description and figures of the Moluccan species, so that I am obliged to look upon the Japanese form as distinct from *A. murrayi*. It differs from that species in the much shorter arms, in the narrower brachial lobes of the disk (narrower outwards than inwards), in the longer genital slits, in the fewer and larger stumpy tubercles in the spaces just proximal to the ventral interbrachial areas, and in the comparatively fewer arm spines. The type specimen measures 34 mm. across disk and 200 mm. in arm length, while *A. murrayi* is described as 29 mm. across the disk and 280 mm. in arm length. The brachial lobes of the disk are not so wide as in *A. murrayi*, and are narrower outwards than inwards, instead of the reverse. The genital slits extend from the inner corners of the ventral interbrachial areas nearly to the disk margin. The spaces just proximal to the ventral interbrachial areas are beset with a few large stumpy tubercles, instead of numerous small ones. First tentacle pore free of arm spines; second with one or two; third, two or three; fourth, three or four; and succeeding, four, or sometimes three. In *A. murrayi*, four or sometimes five arm spines are present at each tentacle pore, even on the very basal arm joints. However, *A. sobrina* is very close to *A. murrayi*, the covering of the disk and arms being quite similar in the two species. But I consider that this similarity is generic rather than specific, as I have observed that the arm covering of the genotype, *A. agassizi*, is also precisely similar to that of the present species.

Five specimens; Sagami Sea.

Order ii. LÆMOPHIURIDA nov.

Radial shield and genital plate articulate with each other by means of a transverse ridge or a simple facet on either plate, without

well-developed articular condyles and sockets. Peristomal plates large, usually entire. Oral frames entire, without well-developed lateral wings. Dorsal arm plates often very small, while the lateral arm plates are very well developed, those of opposite sides usually meeting both above and below.

Key to families of Læmophiurida.

A—Disk and arms delicate and slender; disk scales or plates, as well as arm plates, not very stout, genital plate and scale of either side of a radius articulate with each other, instead of being soldered together; vertebræ not very stout, distal ones often incompletely divided longitudinally by a series of pores.....OPHIACANTHIDÆ.

AA—Disk and arms very heavy; disk and arm plates very stout; genital plate and scale of either side of a radius, firmly soldered together; vertebræ very stout.....HEMIEURYALIDÆ.

Family 1. **OPHIACANTHIDÆ** (Perrier, 1891) Verrill, 1899.

(Characters as given above in key.)

This family includes *Ophiotholia*, *Ophiomyces*, *Ophiologimus*, *Ophiophrura*, *Ophiotoma*, *Ophioblenna*, *Ophiocymbium*, *Ophiopora*, *Ophiotrema*, *Ophiomedea*, *Ophiopristis*, *Ophiolimna*, *Microphiura*, *Ophiomitrella*, *Ophioscalus*, *Ophiocopa*, *Ophiacantha*, *Ophiacanthella*, *Ophiolebes*, *Ophiochondrella*, *Ophiothamnus*, *Ophiomytis*, *Ophioplinthaca*, *Ophiomitra*, *Ophiocamax*, etc.

Ophiacantha bisquamata sp. nov.

Diameter of disk 6 mm. Length of arms 34 mm. Width of arms at base 1.5 mm. Disk pentagonal, with nearly straight or slightly convex interbrachial borders, closely covered with fine granules, of which eight or nine lie in 1 mm. Radial shields entirely concealed, very small, bar-like, separated from each other. Ventral interbrachial areas similar to the dorsal side, but proximally free of granules and covered with fine scales. Genital slits long, nearly reaching the disk margin.

Oral shields small, rhomboidal, with convex inner sides and rounded outer angle, nearly as long as, or slightly longer than wide, in contact with the first lateral arm plates. Adoral shields small, triangular, pointed inwards, meeting each other. Five or six oral papillæ on either side of each jaw; the outermost two are flat and leaf-like, protecting the second oral tentacle pore; the others are very narrow and acute; the innermost one, which pairs with that of the other side, is infradental. Four or five teeth in a single vertical row, more

or less stout, obtuse. Arms composed of rather short and wide joints, uniformly tapered. Dorsal arm plates rhomboidal, with very obtuse inner angle, wider than long, with a more or less distinct median keel, so that the dorsal side of the arm is keeled as a whole. Lateral arm plates with prominent spine ridges, meeting neither above or below. First ventral arm plate very small, quadrangular, with concave inner side, longer than wide; those following, moderately large, pentagonal, with convex, but slightly notched, outer side and rounded outer angles, nearly as long as wide. Six arm spines long, flattened, more or less curved, truncate, translucent, not serrate; uppermost or upper second spine longest, about twice and a half as long as corresponding arm joint; lowest one, shortest, slightly longer than arm joint. Two oval, thin, leaf-like tentacle scales to each pore. Color in alcohol: disk grayish brown, with or without white patches on dorsal side at insertion of arm bases; arms banded with grayish brown and white. The grayish brown and white in alcohol correspond, in life, to dark green and vivid red, respectively.

Two specimens: off Ôshima, Sagami Sea; 75–85 fathoms.

Ophiothamnus venustus sp. nov.

This species is very near *Ophiomitra habrotata* H. L. Clark, but I have some doubt as to the identity of the two species, since certain differences are observable between them as now known. The present species has fine, acute, scattered spines on the disk, without any of the large, conspicuous spines, characteristic of *O. habrotata*. The arm spines of the present species are eight to ten in number to each lateral arm plate on free basal arm joints.

Numerous specimens; off Inatori, Izu, Sagami Bay.

The internal structure of the present species is quite similar to those of the genotype, *O. vicarius* Lyman, the peristomal plates being triple, the genital plates situated above the basal vertebræ, the genital scales absent and the generative glands lined by an unfolded membrane, which contains fine scales, as seen under a microscope.

The species referred to *Ophiothamnus* by modern systematists are of a type not considered *Ophiothamnus* by Lyman, while certain species, which are quite congeneric with Lyman's type of the present genus, have been referred to other genera. For examples, *Ophioleda minima* and *Ophioplinthaca occlusa* of Koehler, and *Ophiomitra habrotata* H. L. Clark, are, in my opinion, genuine *Ophiothamnus*, while *Ophiomitra exigua* Lyman (referred to *Ophiothamnus* by

Verrill), *Ophiomitra dicycla* H. L. Clark, *Ophiothamnus lævis* Lütken and Mortensen, and *Ophiothamnus stultus* Koehler are not genuine *Ophiothamnus*, but belong to a distinct type, which awaits a name, being more or less related to *Ophiomytis* and *Ophioplinthaca*.

Ophiolebes tuberosus sp. nov.

Diameter of disk 10 mm. Length of arms 38 mm. Width of arms at base 1.5 mm. Disk five-lobed, with strongly concave interbrachial borders, deeply hollowed at the central region, covered by a thick, cereous skin, which contains well-spaced, thick, rounded scales of various sizes; beset with several short, conical, stout, obtuse tubercles, which are larger and more numerous on the radial shields. Radial shields also covered by the skin, long, narrow, bar-like, strongly raised, about two-thirds as long as the disk radius. Ventral interbrachial areas covered by a skin similar to that of the dorsal side, the scales and tubercles being, however, smaller. Genital slits large, long, but not reaching disk margin. Oral shields small, thick, rhomboidal, wider than long, with wide, rounded outer angle and convex surface. Adoral shields large, quadrangular, with perfectly rounded outer angles and strongly convex surface, wider without than within, meeting each other. Between each pair of oral plates occurs a more or less distinct buccal pore. Three, or sometimes four, oral papillæ on either side, conical and blunt; inner ones smaller; outermost papilla, very large and stout. Oral papillæ project laterally beyond radial axis, and those on opposite sides of each oral slit are placed alternately. Teeth conical, stout, obtuse.

Arms slender, covered by a thin, cereous skin. Dorsal arm plates two to each joint; proximal plate small, quadrangular, wider than long, with a convex surface; on distal part of arm it becomes longer than wide; distal plate large, fan-shaped, much wider than long, and with a convex surface. Dorsal side of arm bases covered by continuation of disk covering, so that it bears thick, rounded scales of various sizes in place of dorsal arm plates. Lateral arm plates somewhat flaring, meeting below for a short distance. First ventral arm plate comparatively large, hexagonal, with concave inner side and convex surface, widest at the lateral angles, as long as, or slightly longer than, wide, in contact with the next plate; the latter is the largest of all, pentagonal, widest at lateral angles, as long as, or slightly longer than, wide, with convex surface and a conspicuous notch in distal margin; following plates separated from each other, rhomboidal, with a conspicuous notch in distal margin, with strongly convex surface; distally they become smaller, oval or rounded, and

the surface is so convex that they appear like hemispherical tubercles. Arm spines five in number on proximal joints, but four distally; they are conical, blunt, solid, terete; dorsal ones longer and stouter; uppermost about one and a half times, and lowest about two-thirds, as long as corresponding arm joint. Tentacle scales absent. Color in alcohol: yellowish brown.

Numerous specimens; Okinosé (a submarine bank), Sagami Sea.

In younger specimens, the skin, which covers the disk and arms, is very thick and the buccal pores are often indistinct.

Family 2. **HEMIEURYALIDÆ** Verrill, 1899 (emend.).

(Characters as given in key, p. 62.)

Key to subfamilies of Hemieuryalidæ.

A—Dorsal arm plates entire, without supplementary plates; lateral arm plates usually in contact above and below; five to eight arm spines, moderately long, conical; no proper tentacle scales, but lowest arm spine may serve as one, OPHIOCHONDRINÆ.

AA—Dorsal arm plates often accompanied by secondary plates or replaced by a mosaic of small plates; lateral arm plates usually separated above and below; three arm spines and one tentacle scale, all very short and flat..... HEMIEURYALINÆ.

Subfamily 1. OPHIOCHONDRINÆ Verrill, 1899 (emend.).

(Characters as given above in key.)

This subfamily includes *Ophiochondrus*, *Ophiomœris* and *Ophiogyptis*.

Ophiomœris projecta sp. nov.

This species closely resembles *Ophioceramis ? obstricta* Lyman (= *Ophiomœris obstricta* Koehler, 1904 = *Ophiurases obstrictus* Clark, 1911), but differs in two important points. The radial shields are distinctly joined in pairs distally for half their length. A number of large, prominent, spherical tubercles are present on the disk, irregularly arranged along the distal margin of the radial plates, along the joining line of each pair of radial shields, and often also along the outer borders of the same. In the last character, the present species reminds us of *Ophiogyptis nodosa*. The type specimen measures 4 mm. across the disk, 13 mm. in the arm length and 1.5 mm. in the arm width at base. Color in alcohol: disk gray, arms banded with grayish brown and white.

Two specimens; off Ukishima, Uraga Channel; 300 fathoms. One specimen; off Ujishima, Ôsumi.

Subfamily 2. HEMIEURYALINÆ nov.

(Characters as given in key, p. 65.)

This subfamily includes *Sigsbeia*, *Ophioplus*[2] and *Hemieuryale*.

Order iii. GNATHOPHIURIDA nov.

Radial shield and genital plate articulate by means of a conspicuous socket in the former and of a large, ball-like condyle on the latter. Genital plates, as a rule, firmly fixed to the basal vertebræ. Genital scales short, very wide, flattened, leaf-like. On abradial side of innermost part of each genital slit occurs another short, wide, flattened, leaf-like scale, which is firmly attached to oral shield. Peristomal plates small, or rarely large, usually entire, but sometimes double. Oral frames, as a rule, with well-developed lateral wings.

Key to families of Gnathophiurida.

A—Teeth triangular, with pointed ends, not very stout; oral papillæ present; dental papillæ wanting; peristomal plates large, entire; oral frames without well-developed lateral wings; genital scales, short, leaf-like; genital plates free, not fixed to basal vertebræ; distal vertebræ often incompletely divided longitudinally by a series of pores.....AMPHILEPIDIDÆ.

AA—Teeth quadrangular, with wide ends, very stout; peristomal plates small; oral frames very stout with well-developed lateral wings; genital plates firmly fixed to basal vertebræ.

a—Oral papillæ present; no vertical clump of dental papillæ; dorsal side of vertebræ rhomboidal, not U-shaped, AMPHIURIDÆ.

aa—Oral papillæ absent; dental papillæ well developed, forming a vertical clump at apex of each jaw; dorsal side of vertebræ U-shaped.....OPHIOTRICHIDÆ.

Family 1. **AMPHILEPIDIDÆ** nov.

(Characters as given above in key.)

This family includes *Amphilepis* and *Ophiochytra*, besides a new genus, *Amphiactis*. Though almost similar to the next in external features, this family suggests the Ophiacanthidæ in many internal structures.

Amphiactis gen. nov.

Disk covered with imbricating scales, besides moderately large radial shields. Four or five oral papillæ on either side of each jaw, unequal in size, arranged almost in a continuous series. Teeth

[2] *Ophioplus armatus* Koehler, 1907, evidently does not belong to the present subfamily, being, in my opinion, referable to *Ophiolebes*.

triangular, with pointed ends; dental papillæ absent. Peristomal plates large, entire. Oral frames long and slender in internal view, without well-developed lateral wings. Vertebræ of distal arm joints often incompletely divided by a series of pores. Arm spines few. Tentacle scales present, one or two to each pore.

This genus includes *Amphiura canescens*, *duplicata*, and *patula* of Lyman; *Amphiura partita*, *Ophiactis dissidens* and *O. parata* of Koehler, besides the genotype, *Amphiactis umbonata* sp. nov.

Certain representatives of the present genus were referred to *Amphiura* by Lyman, and then to *Ophiactis* by Lütken and Mortensen. *Amphiactis* differs from *Amphiura* and its allies in the absence of paired infradental papillæ, and from *Ophiactis* in the more numerous papillæ, which are arranged in a continuous series so as to close the oral slits. Further, the contrast of the present genus and the *Amphiuridæ* in many internal structures is decidedly striking. *Amphiactis* much resembles *Ophiochytra*, especially *O. tenuis* Lyman, but differs from it in the well-developed radial shields.

Amphiactis umbonata sp. nov.

Diameter of disk 7 mm. Length of arms 30 mm. Width of arms at base 1.2 mm. Disk circular, flat, covered with rather coarse, irregular scales, among which the primaries are distinct. Central plate large, circular, encircled by ten small scales, which correspond to infrabasals and basals in position. Radial plates large, larger than central plate, with strongly curved outer border, which almost forms a semicircle. The central and radial plates have each a small but distinct central boss. The second radials and the first to third interradials may also be distinguished, being larger than the secondary scales, which are irregular in size and in arrangement. Thus, the disk squamation is rather similar to that of Ophiozona. Radial shields comparatively small, oblong ovate, about two-fifths as long as disk radius, twice as long as wide, wider without than within, more convex abradially than adradially, separated by a row of three or four plates, of which the inner ones are larger than the outer. In each interradial area there are five to seven irregularly radiating rows of scales. Ventral interbrachial areas covered with more or less coarse, irregular scales. Genital slits long, nearly reaching disk margin. Genital scales invisible in external view.

Oral shields small, rhomboidal, with acute inner angle, lateral and outer angles rounded, inner sides slightly concave. Adoral shields quadrangular, wider without than within, nearly or quite meeting within. Four oral papillæ on either side, inner ones smaller

and more acute. Deep in oral slits, on either side of each jaw, occurs an additional papilla, which is conical and acute. Five teeth, all obtuse, except uppermost, which is acute.

Arms slender, flattened, uniformly tapering distally. Dorsal arm plates large, fan-shaped, twice as wide as long; inner sides slightly convex, forming an obtuse angle within; distal margin decidedly convex; outer angles rounded; successive plates separated by lateral arm plates, except the basal two or three, which are in contact with each other. Lateral arm plates low, not very prominent. First ventral arm plate small, divided into two secondary plates, of which the inner one is triangular and the outer quadrangular; those following, large, hexagonal (except second, which is pentagonal), much wider than long, widest at outer lateral angles, with concave lateral sides, distal and proximal margins slightly convex; swollen along the outer margins and especially distally, so that arm appears keeled along ventral median line. Arm spines three, subequal, about as long as corresponding arm joint (uppermost slightly longer), cylindrical, tapered and blunt. Two flat, oval tentacle scales to each pore, but sometimes three on the first. Color in alcohol: white.

Two specimens: Sagami Sea.

The internal structures of the present species are essentially similar to those of *Amphilepis norvegica* Ljungman. The peristomal plates are simple, very large. The oral frames are entire, without lateral wings. The oral plates in internal view are very slender and long. The dental plates are absent, so that the teeth arise directly from the oral plates. The genital plates are free from, instead of being fixed to, the basal vertebræ. The genital plate and radial shield of either side of a radius articulate with each other by means of a conspicuous, ball-like condyle on the former and of a large socket in the latter. The genital scales are flat, thin, leaf-like. The vertebræ are very slender, the distal ones being incompletely divided into halves by a series of pores. The first five characters and the last are rather Læmophiuridan, but the other two, the sixth and seventh, are strictly Gnathophiuridan.

Family 2. **AMPHIURIDÆ** Ljungman, 1867 (emend.).

(Characters as given in key, p. 66.)

Key to subfamilies of Amphiuridæ.

A—No paired infradental papillæ ..... OPHIACTININÆ.
AA—Paired infradental papillæ present ..... AMPHIURINÆ.

Subfamily 1. OPHIACTININÆ nov.

(Characters as given above in key).

This subfamily includes *Ophiactis, Hemipholis,*[3] *Ophiopus* and *Ophiopholis.*

Subfamily 2. AMPHIURINÆ.

(Characters as given above in key.)

This subfamily includes *Amphioplus, Amphilimna, Amphiodia, Ophiophragmus, Ophiocnida, Amphipholis, Ophiostigma, Amphiura,*[4] *Ophionema, Paramphiura, Ctenamphiura, Ophiocentrus,*[5] etc.

The first two genera may be grouped as an *Amphioplus*-group, the next three as an *Amphiodia*-group, the following two as an *Amphipholis*-group, and the last five as an *Amphiura*-group. The *Amphipholis*-group are very easily distinguished, while the other three groups are less so. These groups may be distinguished as follows:

Three classes of oral papillæ may be recognized: the first arising from the adoral shields, the second from the oral plates, and the third from the dental plates and being infradental in position. A papilla, which arises partially from the adoral shield and partially from the oral plate, is referred to the second class. Now, let +I indicate the presence of papillæ of the first class, −I the absence of same; +II the presence of papillæ of the second class, etc. Then, the groups of genera are formulized as follows:

Amphioplus-group = +I +II +III.

Amphiodia-group = −I +II +III.

Amphipholis-group = −I +II +III.

Amphiura-group = +I ±II +III.

It may clearly be seen that the *Amphiodia*-group are not intermediate between *Amphioplus*- and *Amphiura*-group, but are, say, the *Amphioplus*-group without the papillæ of the first class, while the *Amphiura*-group are the *Amphioplus*-group without all or most of the papillæ of the second class. I believe that certain species having two distal papillæ, usually referred to *Amphiodia*, are really referable to *Amphiura.*

Applying the same principle to the Ophiactininæ and Ophiotrichidæ, we have the following formulæ:

---

[3] *Hemipholis microdiscus* Duncan, 1870, is evidently a genuine *Amphiura.*

[4] Including *Ophionephthys.*

[5] Including *Amphiocnida.*

Ophiactis = −I +II −III.
Ophiopholis = +I −II −III.
Ophiotrichidæ = −I −II +III.

Ophiophragmus japonicus sp. nov.

Diameter of disk 7 mm. Length of arms 45 mm. Width of arms at base 1 mm. Disk five-lobed, with very convex interbrachial borders, covered with fine, imbricating scales, among which the six primaries are more or less distinguishable. Radial shields semilunar, one-third as long as disk radius, twice as long as wide, joined in pairs, being, however, separated only at proximal end, which is obtusely pointed. A row of large and squarish scales borders disk. Scales of ventral interbrachial areas just outside this marginal series turned up, so as to form the sort of fence characteristic of genus. Marginal scales more elevated than arms; ventral interbrachial areas strongly convex below. Genital slits long.

Oral shields rhomboidal, with inner sides much longer than outer, inner angle very acute, outer and lateral angles rounded; much longer than wide. Adoral shields triangular, tapered within to a point, not meeting each other. Four oral papillæ on either side of each jaw, close-set, subequal, blunt, innermost somewhat stouter.

Dorsal arm plates elliptical, large, outer border curved, inner border strongly convex, forming part of a circle; as wide as arms, twice as wide as long, slightly in contact with each other. Lateral arm plates inserted like so many wedges between successive dorsal arm plates above and ventral plates below; well separated above and nearly so below. First ventral arm plate very small, quadrangular, much wider than long; those beyond pentagonal, with very large inner angle, and slightly notched distal margin, wider than long, only a little in contact with each other. Arm spines three, conical, subequal, blunt, nearly as long as corresponding arm joint. Two very flat, thin tentacle scales; inner one smaller than outer and overlaps its base. Color in alcohol: light yellow.

Numerous specimens; Kagoshima Gulf; 8–15 fathoms. Two specimens; Enoura, Suruga.

This species somewhat resembles *O. affinis* Duncan, especially in number of oral papillæ, but differs from it in shape of radial shields, oral shields and of dorsal arm plates. In my opinion, *Amphipholis andreæ* Lütken, *Amphiura præstans* Koehler and *Amphiodia periercta* H. L. Clark are referable to *Ophiophragmus*, each showing certain affinities to the present species.

Amphipholis japonica sp. nov.

This species is extremely near *A. squamata*, being distinguished from it merely by certain trifling differences. I have compared the Japanese material with specimens of *A. squamata* from Naples. In Neapolitan specimens the arms are two and a half to three times as long as the disk diameter, while in Japanese specimens they are three to four times as long as the same. The distal margin of the ventral arm plates of Neapolitan specimens is nearly straight, while that of Japanese specimens is considerably convex. In the last character the present species resembles *A. australiana* H. L. Clark, differing, however, from that species in the more numerous disk scales of the dorsal side and in the coarser disk scales of the ventral side. The radial shields have each a white spot at the outer end, quite as in *A. squamata*.

Like *A. squamata*, the present species is viviparous. In summer, the larger individuals contain several embryos. I once dissected out six embryos from an adult. Animals containing full-grown embryos appear to give birth to them the night after they are placed in an aquarium.

This species is common in the neighborhood of Misaki, and is found living under stones on fine sand. As to the sensibility of this species to the coarseness of sand, the following observations were made at Arai Beach, Misaki Marine Biological Station. In the summer of 1910, the beach was at first abundantly supplied with small areas among rocks covered with fine sand, and this ophiuran was found very abundantly; after a heavy storm, very few individuals were found, owing to the fact that the spots with fine sand were mostly wiped out. In the summer of 1911, the spots with fine sand were very few, and this ophiuran was seldom found. In the summer of 1912, the beach was entirely covered with coarse sand, and I could no more find this ophiuran. It is a very active species, quickly concealing itself in the sand when the stone is turned up.

Amphiura vadicola[6] sp. nov.

? *Ophionephthys phalerata* Marktanner-Turneretscher (non Lyman, 1874), Ann. K. K. Naturhist. Hofmus., II, 1887, p. 301.

Diameter of disk 8 mm. Length of arms 260 mm. Width of arms at base 1 mm; at the widest part 1.3 mm. Disk five-lobed, with indented interbrachial borders, covered by a soft, naked skin, except along inner and abradial borders of radial shields, where

[6] The interesting life habits of this ophiuran were described by the late Prof. Mitsukuri and Prof. Hara: The Ophiurian Shoal, *Annot. Zool. Jap.*, I, 1897, p. 68.

there are several rows of fine, imbricating scales. Radial shields large, long, pear-seed-shaped; naked part two-thirds to one-half as long as disk radius and about thrice as long as wide. Genital slits long. Genital scales not very conspicuous unless the specimen is dried, arranged in a row and overlapping one another.

Oral shields small, pentagonal, with rounded angles, outer sides longest, inner side slightly concave; madreporic shield much larger than the rest, almost circular. Adoral shields small, triangular, with concave adradial side, meeting neither radially or interradially. Oral plates long and very narrow. There is a more or less conspicuous buccal pore between each pair of oral plates, as in *Ophiothrix*. Two oral papillæ on either side of each jaw, conical, blunt, very stout; the distal one arises from the adoral shield and is longer than the apical one, which arises from the dental plate. Teeth very stout, truncate.

Arms exceedingly long, more than thirty times as long as disk diameter; they are widest at about one-third their entire length from base. Dorsal arm plates almost oval, bounded within by two nearly straight lines, forming a very large and obtuse angle, and without by a curve, which is nearly flat towards median line, but very strong laterally; about twice as wide as long, successive plates slightly in contact with each other. On basal arm joints, they are very small and separated by spaces, which are covered by a naked skin. Lateral arm plates not very prominent, almost covered by arm spines, not meeting above or below, nor in contact on sides, but separated by naked spaces. First ventral arm plate very small, quadrangular, wider than long; those beyond, quadrangular, wider than long, except basal one or two, which are as long as, or longer than, wide; they increase in size, especially in width, outwards, and become pentagonal beyond disk, with large and obtuse inner angle, rounded outer angles and notched distal margin; successive plates separated by narrow spaces where ventral ends of lateral arm plates are wedged in. Ventral arm plates often divided into halves along median line. Arm spines six to seven on basal arm joints, but five or six in middle part of arm, peg-like, flattened, blunt, lower ones longer, nearly equal to, or slightly longer than, corresponding arm joint, much flattened and thorny at end, except the uppermost one or two; next to lowest, spur-shaped and very thorny. Large tentacle pores, without scales. Color in alcohol: brown; the scales around the radial shields are lighter; outer parts of arms grayish-brown to gray.

Numerous specimens; Sakurajima, Kagoshima Gulf.

This species is very near *Ophionephthys phalerata* Lyman, but differs from it in the much larger radial shields, in the not oval but pentagonal oral shields, in the adoral shields, which are not in contact with each other, in the longer oral plates, in the dorsal arm plates being in contact with each other, in the ventral arm plates being separated from each other and not very wide on the basal joints, and in the not cylindrical, but flattened, thorny arm spines.

Amphiura æstuarii sp. nov.

Diameter of disk, 6 mm. Length of arms, 75 mm. Width of arms at base, 0.8 mm. Disk five-lobed, with concave interbrachial borders, covered by a soft, naked skin, except along inner and abradial borders of radial shields, where it is covered by fine, imbricating scales, arranged in four or five rows on inner border, but in only one on outer part of abradial border. Naked part of radial shields large, pear-seed-shaped, more than half as long as disk radius, more than twice as long as wide, hardly in contact without, slightly divergent within. Genital slits long. Genital scales not very distinct.

Oral shields rhomboidal, or pentagonal with a very short inner side, outer angle much rounded; wider than long. Madreporic shield much larger and almost circular. Adoral shields triangular, with concave inner side, tapered within, where they do not meet. Two pairs of oral papillæ to each jaw; apical ones oval and very stout; distal ones conical, obtuse, arising from adoral shields. Teeth stout, truncate.

Dorsal arm plates transversely elliptical, twice as wide as long, successive plates in contact with each other. Lateral arm plates not very prominent, almost covered by arm spines, not meeting above or below, not in contact on sides, but separated by naked spaces. First ventral arm plate very small, pentagonal or quadrangular, wider within than without; those beyond, quadrangular, with convex inner side, notched distal margin, and rounded distal angles; wider than long, except basal one or two; not in contact, but separated by a narrow space, where ventral ends of lateral arm plates are wedged in. Arm spines five, on basal joints, but four in middle part of arm, subequal or lower slightly longer, nearly equal to, or a little longer than, corresponding arm joint; conical and obtuse on proximal joints, but flattened distally; next to lowest spine especially flattened and rather spur-shaped, with numerous thorns on its much flattened tip; lowest spine (as well as second above it) also more or less thorny at tip.

Tentacle pores large, without scales. Color in alcohol: disk gray; radial shields and arms straw-yellow.

Numerous specimens; Aburatsubo Cove: Misaki Marine Biological Station.

A. æstuarii differs from the foregoing species, *A. vadicola*, in the shape of the radial shields, in the much shorter arms, in the dorsal arm plates, which are very wide even on the basal joints, and in the fewer, less flattened arm spines.

A. æstuarii together with *A. euopla* H. L. Clark are easily obtained by dredging in the muddy bottom of Aburatsubo Cove. They probably live buried in mud, as *A. vadicola* does in sand, and I believe that, the reduced disk scales and the numerous thorny arm spines are correlated with the mode of life.

Family 3. **OPHIOTRICHIDÆ** Ljungman, 1867.

(Characters as given in key, p. 66.)

This family includes *Ophiothrix*, *Ophiopteron*, *Ophiocampsis*, *Ophiophthirius*, *Ophiotrichoides*, *Ophiomaza*, *Ophiocnemis*, *Ophiothela*, *Ophiopsammium*, *Ophiogymna*, *Lutkenia*, *Gymnolophus*, *Ophiolophus*, *Ophioæthiops* and *Ophiosphæra*.

Order iv. CHILOPHIURIDA nov.

Radial shield and genital plate articulate with each other by means of two condyles and one pit on either plate. Genital plates and scales bar-like. Peristomal plates small, or sometimes moderately large, usually double or triple. Oral frames with or without well-developed lateral wings. Oral papillæ very well developed, close set, the outermost one usually pointing inwards and stretching above the next papilla, which is the largest as a rule.

Key to families of Chilophiurida (I).

A—Arm spines short, appressed.

a—Disk squamated or tessellated, usually free of granules; oral papillæ thick; arms stout, stoutest at base, inserted laterally to disk ..... Ophiolepididæ.

aa—Disk closely covered with granules.

b—Oral papillæ thick; arms slender, stoutest usually at a distance from base, inserted ventrally to disk; two to four arm spines ..... Ophioleucidæ.

bb—Oral papillæ thin; arms stout, stoutest at base, inserted laterally to disk; numerous arm spines, Ophiodermatidæ, pars.

AA—Arm spines long, not appressed.

c—No vertical clump of dental papillæ.

d—Disk closely covered with granules; arms stout, stoutest at base; numerous arm spines, OPHIODERMATIDÆ, pars.

dd—Disk usually free of granules; arms slender, stoutest at a distance from base..... OPHIOCHITONIDÆ.

cc—Dental papillæ well developed, forming a vertical clump at apex of each jaw; disk often covered with granules; arms stout, stoutest at a distance from base, OPHIOCOMIDÆ.

Key to families of Chilophiurida (II).

A—Teeth not very stout, usually triangular; oral frames entire, without well-developed lateral wings.

a—Second oral tentacle pores open more or less, or entirely, outside oral slits..... OPHIOLEPIDIDÆ, pars.

aa—Second oral tentacle pores open within oral slits.

b—Disk squamated or tessellated, free of granules.

c—Arms stout, stoutest at base; arm spines short, appressed..... OPHIOLEPIDIDÆ, pars.

cc—Arms slender, stoutest at a distance from base; arm spines long, not appressed ..... OPHIOCHITONIDÆ, pars.

bb—Disk covered with granules.

d—Arms slender, stoutest at a distance from base; arm spines few.

e—Arms inserted ventrally to disk; arm spines appressed ..... OPHIOLEUCIDÆ.

ee—Arms inserted laterally to disk; arm spines not appressed..... OPHIOCHITONIDÆ, pars.

dd—Arms stout, stoutest at base; numerous arm spines..... OPHIODERMATIDÆ.

AA—Teeth very stout, quadrangular; oral frames with well-developed lateral wings.

f—No vertical clump of dental papillæ.

g—Arms stout, stoutest at base; arm spines short, appressed. OPHIOLEPIDIDÆ, pars.

gg—Arms slender, stoutest at a distance from base; arm spines long, not appressed..... OPHIOCHITONIDÆ, pars.

ff—Dental papillæ well developed, forming a vertical clump at apex of each jaw, OPHIOCOMIDÆ.

Family 1. **OPHIOLEPIDIDÆ** Ljungman.

(Characters as given above in keys.)

Key to subfamilies of Ophiolepididæ.

A—Second oral tentacle pores open more or less, or entirely, outside oral slits..... OPHIOMASTINÆ.

AA—Second oral tentacle pores open entirely within oral slits, OPHIOLEPIDINÆ.

Subfamily 1. OPHIOMASTINÆ nov.

(Characters as given in key p. 75.)

This subfamily includes *Ophiomastus*, *Ophiotypa*, *Ophiomisidium*, *Ophiophycis*, *Anthophiura*, *Ophiopyrgus*, *Ophiochrysis*, *Ophiosteira*, *Gymnophiura*, *Ophiura*, *Ophionotus*, *Ophioperla*, *Ophiotjalfa*, *Ophiogona*, *Ophioplinthus*, *Ophiopleura*, *Ophiocten* and provisionally *Astrophiura*, besides five new genera, *Haplophiura*, *Aspidophiura*, *Amphiophiura*, *Stegophiura* and *Ophiurolepis*.

Koehler's recently described genus *Ophiomisidium* includes *Ophiomusium pulchellum* Wyville Thomson, *O. flabellum* Lyman, and *O. speciosum* Koehler, the last being the genotype. The group evidently stands between *Ophiomastus* and *Ophiophycis* in systematic position.

HAPLOPHIURA gen. nov.

Disk high, much elevated above arms, covered above with plates and scales, among which the primaries are very prominent, and below with close-set, fine granules. Radial shields stout, joined in pairs. Oral papillæ soldered together. Genital plates and scales present, but invisible in external view. Genital bursæ absent and genital slits invisible. Arms short, low, wider than high, covered with convex arm plates. Tentacle pores, including second oral ones, which open entirely outside oral slits, naked, being free from scales. Arm spines few, minute.

This new genus contains only a single species, *Ophiozona gymnopora* H. L. Clark.

ASPIDOPHIURA gen. nov.

Disk rather high, elevated above arms, flat, covered with very stout primaries and radial shields, besides often a few smaller scales. Ventral interbrachial areas covered by a very large plate, besides very stout genital scales. Arm combs and genital papillæ present. Oral shields purse-shaped, with a beak-like inner process. Oral papillæ soldered together. Second oral tentacle pores open entirely outside oral slits, slit-like, guarded by numerous small scales. Arms rather short, strongly knotted, with long arm joints. Dorsal arm plates very rudimentary or entirely absent. Ventral arm plates small, rhomboidal or triangular. Tentacle pores present only on several proximal arm joints, provided with few or no scales. Three short, conical arm spines.

This genus includes *Ophioglypha minuta* Lyman and *O. forbesi* Duncan (= *Ophiura glyptodisca* H. L. Clark), besides the genotype,

Aspidophiura watasei sp. nov. It stands rather between *Anthophiura* and a certain group of *Amphiophiura* with very conspicuous ventral interbrachial plates.

Aspidophiura watasei sp. nov.

This species is very near *A. forbesi*, but differs from it chiefly in the presence of a central boss to each of the six primary plates, in the smaller radial shields, which are about as large as the radial plates, in the ventral arm plates, which more rapidly diminish in size outwards, in the longer arm spines, which are longer than half the corresponding arm joint, and in the absence of tentacle scales beyond the disk.

The present species differs from *A. minuta* chiefly in the presence of a central boss to each of the six primaries, in the smaller radial shields and in the better-developed arm combs.

The type specimen is 5 mm. across the disk with arms probably about twice the disk diameter, and 1.3 mm. in width. Color in alcohol: disk yellowish gray above and white below; arms white.

One specimen; Sagami Sea. One specimen; Uraga Channel.

AMPHIOPHIURA gen. nov.

Disk high, often convex, covered with plates and scales, among which the primaries are very prominent. Radial shields stout, joined in pairs. Arm combs and genital papillæ present. Oral shields oval, pyriform or trefoil. Second oral tentacle pores open more or less, or entirely, outside oral slits; large, guarded by numerous scales. Arms moderately long, gradually tapering outwards, with blunt tips. Dorsal and ventral arm plates fairly well developed; successive plates in contact with each other at least on proximal arm joints. Lateral arm plates high, with few to numerous short, peg-like arm spines. Tentacle pores large, with numerous scales.

This new genus includes *Ophioglypha bullata* Wyville Thomson, which is here designated as the genotype; also the following species with very conspicuous oral shields, which almost cover the ventral interbrachial areas, *O. convexa* Lyman and *O. insolita, improba*, and *abdita*, of Koehler; also the following species with very conspicuous ventral interbrachial plates, *O. solida* and *scutata* of Lyman, *O. stellata* Studer, *O. paupera, sordida, liberata, urbana, remota*, and *latro* of Koehler, and *Ophiura ædiplax* and *pompophora* of H. L. Clark; also the following species with the ventral interbrachial areas covered with many scales and having quadrangular ventral arm plates, *Ophioglypha sculptilis* (= *O. variabilis*) *lacazei, lapidaria*,

and *undata* of Lyman, *O. prisca*, *laudata*, and *distincta* of Koehler, and *Ophiura megapoma*, *hadra*, and *penichra* of H. L. Clark; also the following species with the ventral interbrachial areas covered with many scales, and having axe-shaped ventral arm plates, *Ophioglypha radiata* and *ornata* of Lyman, and *O. abcisa* and *obtecta* of Lütken and Mortensen.

The group with very large oral shields or with very conspicuous ventral interbrachial plates approaches *Ophiopyrgus* on the one hand and *Aspidophiura* on the other; the group with ventral interbrachial areas covered with many scales and with quadrangular ventral arm plates approaches *Gymnophiura* on the one hand and *Stegophiura* (*vide infra*) on the other; and the group with ventral interbrachial areas covered with many scales, and with axe-shaped ventral arm plates, approaches true *Ophiura*, restr. (*vide infra*).

GYMNOPHIURA Lütken and Mortensen, 1899 (restr.).

Disk high, covered by a naked skin. Radial shields long, narrow, bar-like, widely separated from each other, covered by skin. Arm combs and genital papillæ present. Oral shields comparatively small, pentagonal, with notched lateral sides. Second oral tentacle pores opened partially outside the oral slits, large, with numerous scales. Arms moderately long, very gradually tapered outwards, with blunt extremity. Dorsal and ventral arm plates well developed, successive plates widely in contact with each other. Lateral arm plates high, with numerous minute, peg-like arm spines. Tentacle pores large, with numerous scales.

This genus, as restricted, contains but a single species, *G. mollis* Lütken and Mortensen. Another species, viz., *G. cærulescens*, is, in my opinion, referable to genuine *Ophiura*, and is probably conspecific with, or at least closely allied to, *Ophiura flagellata* (Lyman).

Gymnophiura is very near *Amphiophiura*, especially the group with ventral interbrachial areas covered with many scales, and with quadrangular ventral arm plates, but differs from it in the naked disk and in the radial shields, which are narrow, bar-like, skin-covered and widely separated from each other.

STEGOPHIURA gen. nov.

Disk high, covered with plates and scales, among which the primaries are prominent. Radial shields stout, joined distally. Arm combs and genital papillæ present. Oral shields oval or pyriform. Second oral tentacle pores open more or less, or entirely,

outside oral slits, large, provided with numerous scales. Arms very short, very stout at base, higher than wide, rapidly tapering distally, with acute tip. Dorsal and ventral arm plates well developed, successive plates widely in contact with each other. Lateral arm plates high, with numerous arm spines, often unequal and arranged in two series. Tentacle pores large, with numerous scales.

This genus includes *Ophiura nodosa* and *stuwitzii* of Lütken, *Ophioglypha elevata* Lyman, *O. sculpta, sladeni* (= *Ophiura stiphra* H. L. Clark), and *striata* of Duncan, and *O. sterea* and *Ophiura brachyactis* of H. L. Clark, besides a new species, *Stegophiura vivipara.*

The genotype is *Ophiura nodosa* Ltk. *Stegophiura* much resembles a certain group of *Amphiophiura*, but differs in the shorter, stouter and more rapidly tapering arms with more acute tips.

Stegophiura vivipara sp. nov.

Diameter of disk 6 mm. Length of arms 13 mm. Width of arms at base 1.5 mm. Disk pentagonal, or circular (especially when the animal contains many embryos), convex, covered with fifty to sixty plates on the dorsal side, including the radial shields. Central plate pentagonal. Five pentagonal radials, directly surrounding the central plate, laterally overlapping each other. In each interradial space of dorsal side is a large squarish plate, wider than long, in contact with radial shields; latter irregular in outline, about as wide as long, one overlapping the other, instead of apposed to each other in radial line. On ventral side of disk plates rounded and knob-like, with furrows between. Genital papillæ blunt, close-set, longer outwards and upwards, where they form small arm combs. Oral shields pear-shaped, much longer than wide, wider without than within, with acute inner angles and perfectly rounded distal margins. Adoral shields large, meeting within along their whole length. Five oral papillæ on either wide, squarish, short, wide, close-set; a pair of infradental papillæ at apex of each jaw, much longer and stouter than the other oral papillæ, rather obtusely pointed. Five teeth, very small, close-set, obtusely pointed. Arms very short, stout at base, rapidly tapered distally. Dorsal arm plates fan-shaped, about as wide as long, convex dorsally. Lateral arm plates convex, those of the two sides separated both above and below on the basal arm joints. First ventral arm plate large, triangular, with obtuse inner angle and convex outer side, wider than long; the following plates are octagonal, with very short proximo-lateral and disto-lateral sides, the former concave at tentacle pores; wider than long, wider without than within; from the six or seventh

outwards, the plates are longer than wide, hexagonal, with very short proximal and proximo-lateral sides, concave lateral margins and a very convex distal side. Arm spines seven or eight, including the tentacle scales, on the free basal joints, fine, conical, short; middle ones longer than upper and lower ones, and about half as long as corresponding arm joint; diminishing in number outwards; the lower spines are much finer and serve as tentacle scales. Second oral tentacle pore, very large, opening outside oral slit, bounded by three or four scales on each side. Tentacle pores large, guarded on basal joints by one to three aboral scales, besides the lower arm spines on the adoral side. Color in alcohol: pale gray.

Numerous specimens; Sagami Sea. Numerous specimens; Sagami Sea, 75 and 100 fathoms.

This species is viviparous. I once dissected out twenty-four embryos of various sizes from a single adult.

OPHIUROLEPIS gen. nov.

Disk covered with larger rounded plates and smaller scales, the former surrounded by belts of the latter. Radial shields moderately large, rounded, separated from each other. Adoral shields oval, with rounded inner border and obtusely pointed outer end. One to three supplementary plates are present in each space between the adoral shields and oral plates. Teeth and oral papillæ present, the latter very close set. Arm combs, as well as genital papillæ, absent. Arms long, stout, very gradually tapered. Dorsal arm plates very well developed, widely in contact with each other. Lateral arm plates low. Ventral arm plates triangular, nearly or scarcely in contact with each other. Second oral tentacle pores open entirely outside oral slits, long, slit-like, closed by tentacle scales, which are modified so as to appear like supplementary plates. A single arm spine and three tentacle scales, both being minute and peg-like.

This new genus contains a single species, *Ophiolepis carinata* Studer, 1876 (= *Ophioglypha deshayesi* Lyman).

Ophiurolepis is very peculiar in every feature, as it is certainly not referable to *Ophiura*, even in a wide sense. The disk squamation reminds us of that of *Ophiolepis*.

OPHIURA Lamarck, 1816; Forbes, 1839 (restr.).

Synonyms: *Ophioglypha* Lyman, 1860; *Ophioglyphina* Ludwig, 1886.

Disk low, flat, covered with plates and scales, among which the primaries are usually very prominent. Radial shields usually

separated from each other, sometimes more or less joined in pairs. Second oral tentacle pores open nearly or entirely outside oral slits, very large, beset with numerous scales. Genital papillæ, and usually also arm combs, present. Arms low, often flattened. Dorsal arm plates usually well developed and in contact with each other. Lateral arm plates low, those of the two sides being in contact with each other below. Three or more arm spines of variable length. Tentacle pores of one or two innermost pairs large and beset with rather numerous scales, but those beyond very small and beset with a few scales.

This genus, as here restricted, includes *Asterias ciliata* Retzius and the following species with spiniform genital and comb-papillæ: *Ophiura albida* Forbes, *Ophiolepis robusta* Ayres, *Ophiura sarsii*, *arctica*, *carnea*, and *affinis* of Lütken, *O. kinbergi* Ljungman, *O. hexactis* and *brevispina* of Smith, *O. acervata*, *inermis*, *papillata*, *flagellata* (= *Gymnophiura cærulescens* Lütken and Mortensen), *imbecillis*, *lepida*, *æqualis*, *ljungmani*, and *meridionalis* of Lyman, *O. aurantiaca* Verrill, *O. maculata* Ludwig, *O. amphitrites* Bell, *O. indica* Brock, *O. thouleti* Koehler, *Ophiozona capensis* Bell, *Ophiura leptoctenia*, *micracantha*, *quadrispina*, *bathybia* and *Ophiocten oöplax* H. L. Clark; also the following species with blunt and flat genital and comb papillæ, *Ophioglypha multispina* and *lymani* Ljungman, *O. lutkeni*, *irrorata*, *undata*, *costata*, *albata*, *jejuna*, *loveni*, *fraterna*, *rugosa*, *inornata*, *confragosa*, *intorta*, *ambigua*, *abyssorum*, *tenera* and *falcifera* of Lyman, *O. verrucosa* Studer, *O. inflata*, *clemens*, *concreta*, *mundata* and *aspera* of Koehler, *O. plana*, *scutellata*, *nana* and *obtecta* of Lütken and Mortensen, *O. tessellata* Verrill, *Ophiura clasta*, *monostæcha*, *atacta*, *calyptolepis* and *cryptolepis* of H. L. Clark.

Ophionotus, *Ophioperla* and *Ophiotjalfa* are very close to the present genus—especially to the typical group with spiniform genital and comb papillæ and with rather long arm spines. *Ophionotus* may be defined as typical *Ophiura* with supplementary dorsal arm plates; *Ophioperla* as Ophiura with granulated disk; and *Ophiotjalfa* as Ophiura without genital papillæ and arm combs.

Subfamily 2. OPHIOLEPIDINÆ nov.

(Characters as given in key, p. 75.)

This subfamily includes *Ophiomusium*, *Ophiolipus*, *Ophiophyllum*, *Ophiopenia*, *Ophiocrates*, *Ophiomidas*, *Ophiothyreus*, *Ophiozona*, *Ophioceramis*, *Ophiolepis* and *Ophioplocus*, besides a new genus, *Ophiozonella*, which is separated from *Ophiozona*.

OPHIOZONELLA gen. nov.

Disk covered with stout plates, mingled with smaller ones. Radial shields very large; those of both sides of a radius separated from each other by a single row of plates, or more or less in contact with each other. No distinct trio of plates just outside and between each pair of radial shields. Oral and adoral shields rather large. Teeth and oral papillæ present; the latter are thick and close-set. Genital slits short, not reaching disk margin. Arms not very long, stout at base, rather rapidly tapering distally to a slender and acute tip. Dorsal and ventral arm plates rhomboidal, successive plates separated from each other, at least, distal to arm base. Arm spines two to four, short. One or two tentacle scales to each pore.

This new genus includes the following species with two tentacle scales: *Ophiozona nivea*, *tessellata*, *marmorea* and *clypeata* of Lyman, *O. bispinosa* and *molesta* of Koehler, and *O. elevata* and *platydisca* of H. L. Clark; and the following with only one tentacle scale: *O. insularia stellata*, *antillarum* and *depressa* of Lyman, *O. alba* and *contigua* of Lütken and Mortensen, *O. casta* and *projecta* of Koehler, *O. tjalfiana* Mortensen, and *O. polyplax* and *longispina* of H. L. Clark. The genotype is *Ophiozona longispina* H. L. Clark.

Ophiozonella includes deep-water forms and is allied to such genera as *Ophiocrates* and *Ophiomidas*, while genuine *Ophiozona* includes littoral forms and is very close to *Ophiolepis* and *Ophiothyreus*.

OPHIOZONA Lyman, 1865 (restr.).

Disk covered with very numerous small plates and scales, the larger surrounded by belts of smaller. Radial shields small, widely separated from each other by several plates and numerous scales. A noticeable trio of plates is distinguishable just outside and between each pair of radial shields. Oral and adoral shields small. Teeth and oral papillæ present, latter very thick and close-set. Genital slits rather long. Arms long, rather slender, very gradually tapering distally, with blunt tips. Dorsal, as well as ventral, arm plates well developed, quadrangular, successive plates widely in contact with each other throughout the entire length of the arm. Four or five short, peg-like arm spines. Two tentacle scales to each pore, more or less oval in common outline.

This genus, as here restricted, includes only *Ophiolepis impressa* and *pacifica* of Lütken (the two species on which *Ophiozona* was based by Lyman). The genotype is *O. impressa*.

The Ophiolepidinæ comprises two groups, one of which includes

genera with well-developed, quadrangular dorsal and ventral arm plates and the other those with more or less rudimentary dorsal and ventral arm plates. The first group, including littoral forms, is again divided into two sections, one of which, including *Ophiothyreus*, *Ophiozona* and *Ophiolepis*, is characterized by the presence of a distinct trio of plates just outside and between each pair of radial shields and by the presence of two tentacle scales, which are oval in common outline; while the other, including *Ophioceramis* and *Ophioplocus*, is characterized by the absence of a distinct trio of plates just outside and between each pair of radial shields, and by the presence of three to five tentacle scales, which surround the pore. The distinction of *Ophiolepis* and *Ophiozona* from each other depends upon the presence or absence of supplementary dorsal arm plates. From a certain point of view, I believe that *Ophiozona* is more closely allied to *Ophiolepis* than to *Ophiozonella*. *Ophiozona* is found in the West Indies and on the Pacific side of Panama. The faunæ of the two sides of Panama stand in a very intimate relation to each other. The distribution of *Ophiozona* and that of *Ophioderma* are equally interesting as illustrating this truth.

Family 2. **OPHIOLEUCIDÆ** nov.

(Characters as given in keys, pp. 74 and 75.)

This family includes *Ophiopœpale*, *Ophiocirce*, *Ophioleuce*,[7] *Ophiopallas*, *Ophiotrochus*, *Ophiernus* and *Ophiopyren*.

Family 3. **OPHIODERMATIDÆ** Ljungman, 1867.

(Characters as given in keys, pp. 74 and 75.)

Key to subfamilies of Ophiodermatidæ.

A—Arm spines rather long, not appressed; distal vertebræ sometimes imperfectly divided into halves by a series of pores, OPHIARACHNINÆ.

AA—Arm spines very short, appressed; vertebræ always entire, OPHIODERMATINÆ.

Subfamily 1. OPHIARACHNINÆ nov.

(Characters as given above in key.)

This subfamily includes *Ophiarachna* and three new genera, *Ophiuroconis*, *Ophiurodon* and *Ophiurochæta*.

---

[7] *Ophiocten charischema* H. L. Clark, 1911, and *O. brevispinum* H. L. Clark, 1911, are, in my opinion, referable to *Ophioleuce*.

Key to the genera Ophioconis, Ophiochæta and *Ophiolimna* in wide sense.

A—Arm spines long, flagellate, not appressed.

a—Outermost oral papilla very large and operculiform; peristomal plates very short and wide, nearly entire, with fairly soldered halves and without a third median secondary plate..... *Ophiolimna*, emend.

aa—Outermost oral papilla pointed inwards, stretching above the next papilla, which is the largest; peristomal plates rather long and wide, distinctly triple, consisting of two paired and one median secondary plates.

b—Oral shields entirely covered with granules; arm plates usually concentrically striated; vertebræ of distal arm joints often divided into halves; arm spines hyaline; one or two tentacle scales, neither of which overlaps base of lowest arm spine.

c—Teeth triangular and pointed, not hyaline; ventral arm plates wider than long, usually separated from each other..... *Ophiuroconis* nov.

cc—Teeth flat, thin, with widened and often serrate end, hyaline; ventral arm plates longer than wide, distinctly in contact with each other..... *Ophiurodon* nov.

bb—Oral shields naked; arm plates not concentrically striated; vertebræ always entire; arm spines opaque; two tentacle scales, of which the abradial one overlaps base of lowest arm spine..... *Ophiurochæta* nov.

AA—Arm spines very short, peg-like, lying flat on arm.

d—Oral shields covered with granules; arm spines hyaline..... *Ophioconis*, restr.

dd—Oral shields naked.

e—Arm spines hyaline; disk covered with granules, *"Ophioconis" indica.*

ee—Arm spines opaque; disk covered with fine spines..... *Ophiochæta*, restr.

Ophiolimna, emend., includes *Ophiacantha bairdii* Lyman (referred to *Ophiolimna* by Verrill), *Ophioconis antarctica* Lyman, *Ophiacantha perfida* Koehler, *Ophiolimna operculata* Koehler, *Ophioconis diastata* and *papillata* of H. L. Clark and *Ophiacantha lambda* H. L. Clark, and belongs to the Ophiacanthidæ. *Ophiuroconis* includes *Ophioconis pulverulenta* and *miliaria* of Lyman, besides the genotype, *Ophiuroconis monolepis* sp. nov. *Ophiurodon* includes *Ophioconis cincta* Brock, *O. grandisquama, permixta* and *cupida* of Koehler. *Ophiurochæta* includes *Ophiochæta mixta* Lyman (referred to *Ophiolimna* by Verrill) and *Ophiolimna littoralis* Koehler. The last three genera belong to the Ophiarachninæ; especially *Ophiurochæta* is very near *Ophiarachna. Ophioconis*, restr., includes *Pectinura, forbesii* Heller (referred to Ophioconis by Lütken) and *Ophioconis*

brevispina Ludwig. *Ophiochæta* contains only *O. hirsuta* Lütken. Genuine *Ophioconis* much resembles *Cryptopelta*, but has, however, hyaline arm spines. Genuine *Ophiochæta* appears to be very near *Pectinura*, but is, however, covered with fine spines, instead of granules, on the disk. "*Ophioconis*" *indica* Koehler, which I do not dare to name generically, as I have not myself examined it, appears to resemble *Pectinura*, except for the hyaline arm spines and the presence of a single tentacle scale on most of the tentacle pores, instead of two.

OPHIUROCONIS gen. nov.

Disk and oral angles, including oral shields, closely covered with fine granules. Six or seven oral papillæ on either side of each jaw; outermost one pointed inwards, stretching above next papilla, which is the largest. Teeth triangular and obtusely pointed. Arms not very long, cylindrical, widest at the base, tapering outwards to the very slender tip, where the vertebræ are imperfectly divided into halves by a longitudinal series of pores. Ventral arm plates wider than long, not in contact with each other, except on the most proximal joints. Arm spines six or more, more or less long, flattened, hyaline and not appressed. One or two tentacle scales to each pore.

Ophiuroconis monolepis sp. nov.

This species is at once distinguished from both *O. pulverulenta* and *miliaria* by fewer oral papillæ, by fewer and shorter arm spines and by the presence of a single tentacle scale, instead of two, to each pore. Oral papillæ, six or seven in number on either side of each jaw, close-set and acute. Each lateral arm plate bears six or seven arm spines, which are rather spiniform, acute, slightly flattened and hyaline; uppermost one or two spines nearly twice as long as, and lowest one slightly shorter than, corresponding arm joint. A single small, leaf-like, but acutely pointed, tentacle scale at each pore. Dorsal arm plates, rather small, fan-shaped, not in contact with each other, wider than long, convex along median line, so that the arm is keeled dorsally as a whole. Ventral arm plates, very small, much wider than long, much shorter than corresponding arm joint. All the dorsal, lateral and ventral arm plates are concentrically striated.

The type specimen is 5 mm. across disk, 25 mm. in arm length and 1 mm. in arm width at base. Color in alcohol: light yellow.

Six specimens; Sagami Sea, 85 fathoms. Two specimens; Sagami Sea, 300 fathoms.

OPHIURODON gen. nov.

Disk and oral angles, including oral shields, closely covered with fine granules. Four or five oral papillæ on either side of each jaw; outermost pointed inwards, stretching above next papilla. Teeth flat, thin, with widened and often serrate end. Arms not very long, widest at base, tapering outwards to the very slender tip. Ventral arm plates very narrow, longer than wide, distinctly in contact with each other. Vertebræ of distal arm joints often imperfectly divided into halves by a longitudinal series of pores. Six or more arm spines, long, flattened, hyaline, not appressed. Single tentacle scale to each pore.

The genotype is *Ophioconis grandisquama* Koehler, and it is worth noting that a specimen of this species was recently collected at Okinosé (a submarine bank), in the Sagami Sea.

OPHIUROCHÆTA gen. nov.

Disk closely covered with fine granules and sparsely beset with fine spines. Oral angles also granulated, but oral shields naked. Numerous close-set oral papillæ, of which outermost one is pointed inwards, stretching above next papilla, which is the largest. Teeth triangular and obtusely pointed. Arms not very long, rather stout, stoutest at base. Dorsal, as well as ventral, arm plates well developed, widely in contact with each other. Six or more arm spines, long, flagellate, opaque, not appressed. Two tentacle scales to each pore, abradial one overlapping base of lowest arm spine.

The genotype is *Ophiochæta mixta* Lyman.

Ophiurochæta differs from *Ophiolimna* in the following important particulars: more numerous oral papillæ, of which the outermost one is not operculiform, but pointed inwards above the next papilla, which is the largest; well-developed dorsal and ventral arm plates, which are widely in contact with each other, two tentacle scales, of which the abradial one distinctly overlaps the base of the lowest arm spine; triple peristomal plates. Verrill considers that the internal structures of *O. mixta* are much like those of *Ophiacantha;* but my own opinion is quite to the contrary.

I have observed that the internal structures of *Ophiuroconis monolepis*, *Ophiurodon grandisquama*, *Ophiurochæta mixta*, *Ophiarachna incrassata*, *Ophiochiton fastigatus*, *Ophioplax lamellosa*, etc., belong to a common type. In them the peristomal plates are always triple, consisting of two paired and one median secondary plates; while in *Ophiacantha*, *Ophiolimna*, etc., the peristomal plates are

entire, or double with soldered halves, and always lack a third, median secondary plate. Further, the peristomal plates of the former type are distinctly longer in proportion to their width than are those of the latter.

Ignoring the smaller size, *Ophiurochæta* much resembles *Ophiarachna*, the only essential differences being the presence of scattered disk spines and the absence of accessory oral shields. The systematic value of the accessory oral shields is, however, considered insignificant by Dr. H. L. Clark. I have also observed the absence of the accessory oral shields in some interradii of a specimen of *Ophiarachna incrassata*. One may safely say, then, that the relation of *Ophiurochæta* to *Ophiarachna* is parallel to that of *Ophiomastix* to *Ophiocoma* or of *Ophiochæta* to *Pectinura*.

Subfamily 2. OPHIODERMATINÆ nov.

(Characters as given in key, p. 83.)

This subfamily includes *Ophioconis*, restr., *Cryptopelta*, *Bathypectinura*, *Pectinura*, *Ophiopezella*, *Ophiochæta*, *Ophiarachnella*, *Ophiochasma*, *Ophioderma*, *Ophioncus* and *Diopederma*.

Bathypectinura gotoi sp. nov.

Diameter of disk 50 mm. Length of arms 195 mm. Width of arms at base 7 mm. Disk pentagonal, flat, closely covered with fine granules, of which four or five are contained in 1 mm. Radial shields only partly naked, but distinguishable through the superficial granulations, by the slight swelling, as large, elongated ovate plates, nearly half as long as disk radius, wider outwards; naked part very small, ovate, and wider without than within. Genital slits very long, almost reaching disk margin. Genital plates visible from exterior, lying along adradial border of slits, long, very stout.

Oral shields small, triangular, with rounded angles and convex sides, nearly as wide as long. Accessory oral shields very rudimentary; in one of the two specimens they are absent, but in the other they are indistinctly represented by one or two small scales, which are separated from the oral shield by granules. The adoral shields are almost, and the oral plates entirely, covered with granules, which are coarser and sparser than distally. Eight or nine oral papillæ on either side; outermost two or three large, flat, thin, outer second largest; inner ones small, more or less conical, obtuse. Five to seven teeth, irregular in shape and size, with pointed or rounded ends, arranged in an irregular vertical row.

Arms long, stout, gradually tapered outwards, with a rather sharp

dorsal median ridge, triangular in transverse section. Dorsal arm plates large, occupying almost entire dorsal surface of arm, quadrangular, with rounded outer corners, a little wider without than within, three to four times as wide as long, with a rather sharp ridge on the median line; some are divided into several irregular secondary plates. Lateral arm plates very low, less than half height of arm, meeting neither above nor below. Ventral arm plates small, rhomboidal, with shorter diameter parallel to arm axis. First plate almost as wide as, but much shorter than, following; the three or four plates beginning with the second have a median keel, which is more prominent proximally both with regard to each plate and to the arm as a whole. Arm spines four for the most part, but three distally, very short, flattened, lanceolate, obtuse, lowest one somewhat longer than the others, but not so long as corresponding arm joint. One tentacle scale, large, oval, thin, flat. Color in alcohol: light yellowish brown.

Two specimens; Sagami Sea, 170 fathoms.

This new species is very near *B. lacertosa* (Lyman), but differs from it in the coarser disk granules, in the smaller naked part of the radial shields, in the more strongly ridged dorsal arm plates, in the much lower lateral arm plates, in the wider and rhomboidal ventral arm plates, and in the shorter arm spines.

Family 4. OPHIOCHITONIDÆ nov.

(Characters as given in keys, pp. 74 and 75.)

Key to subfamilies of Ophiochitonidæ.

A—Teeth triangular, not very stout; peristomal plates moderately large; oral frames entire, without well-developed lateral wings; dorsal side of vertebræ entire, rhomboidal ....OPHIOCHITONINÆ.

AA—Teeth quadrangular, very stout; peristomal plates very small; oral frames with well-developed lateral wings; dorsal side of vertebræ notched inwards and V-shaped..... OPHIONEREIDINÆ.

Subfamily 1. OPHIOCHITONINÆ nov.

(Characters as given above in key.)

This subfamily includes *Ophiochiton*[8] and *Ophioplax*.

Ophioplax lamellosa sp. nov.

This new species is quite near *Ophioplax ljungmani*, *Ophiopeza custos* Koehler (referred to *Ophioplax* by Koehler) and *Ophiopeza*

[8] *Ophiochiton lymani* Studer, 1883, is, in my opinion, referable to *Ophiocten*, being allied to *Ophiocten hastatus* Lyman, *O. pacificum* Lütken and Mortensen, etc.

reducta Koehler (referred to *Bathypectinura* by Dr. H. L. Clark).[9] It is, however, distinguished from *O. ljungmani* by the presence of primary disk plates, by coarser disk scales, by shape of radial shields, by the disk margin being not so closely granulated, and by the shape of the oral shields; from *O. custos* by the presence of primary disk plates, by coarser disk scales, by the shape of the radial shields, by the adoral shields not meeting each other within, by the shape of the first and second ventral arm plates, by the presence of lamellar plates at the arm bases, and by shape of dorsal arm plates; and from *O. reducta* by dorsal side of disk being free of granules, by radial shields not being divergent, and by shape of ventral arm plates. Disk covered with fine, imbricating scales, among which the six primaries are more or less distinct; the radial plates are smaller and less conspicuous than the central plate. Radial shields triangular, with acute inner angles, twice as long as wide; those of a pair are nearly parallel, being separated from each other. Ventral interbrachial areas are closely covered with very fine granules. Oral shields large, triangular, with strongly curved outer border, less curved lateral sides, obtuse inner angle and perfectly rounded lateral angles. Adoral shields large, triangular, long, tapered within to an acute point, but they do not meet. Lamellar plates and fine granules occur on dorsal and lateral surface of free arm bases. Dorsal arm plates triangular at first, but soon becoming quadrangular with rounded outer corners and curved lateral borders, much wider without than within. First ventral arm plate is small, triangular, with rounded-angles, nearly as wide as long; those beyond are pentagonal, with an inwardly directed angle, which is covered by the preceding plate; outer border curved, and lateral borders concave and bounded by tentacle pores. A single large, oval tentacle scale occurs on the abradial side of each pore; besides, on the adradial side of a few basal pores, there are present one or two rudimentary tentacle scales, more or less covered over by the abradial one.

The type is 4.5 mm. across the disk, 35 mm. in arm length and 0.8 mm. in arm width at base. Color in alcohol: yellowish gray above and white below; arms banded with dark gray.

One specimen; off Kôtsujima, Sagami Sea.

It is recorded that the above specimen was taken with a coral-net,

[9] *Ophiopeza reducta* appears to me to be referable to *Ophioplax*. The presence of only three long, cylindrical arm spines and of only five oral papillæ, the annulation on the arms and the naked oral plates are all characters of *Ophioplax*, but not of genuine *Bathypectinura*.

but the depth is not stated. As the annulation on the arms indicates, this species is not a deep-water form, but probably sublittoral.

Subfamily 2. OPHIONEREIDINÆ Ljungman, 1867 (emend.).

(Characters as given in key, p. 88.)

This subfamily includes *Ophiodoris*, *Ophionereis* and *Ophiocrasis*.

OPHIOCRASIS H. L. Clark, 1911.

Aside from the presence of the secondary supplementary dorsal arm plates, this genus seems to me to be distinguished from *Ophionereis* principally by negative characters and different degrees of development of certain common structures. Disk scales even and exceedingly fine; no trace of marginal row of special disk scales; no genital papillæ; arms much more slender than in *Ophionereis*. Schizogonic reproduction may not be a generic character.

Ophiocrasis marktanneri sp. nov.

Ophionereis porrecta, Marktanner-Turneretscher (non Lyman, 1860), Ann. K. K. Naturh. Hofmus., II, 1887, p. 302, Pl. XII, fig. 18.

"*Ophionereis porrecta* Marktanner," Koehler, Bull. Sci. Fr. Belg., XXXI, 1898, p. 76.

Diameter of disk 9 mm. Length of arms 68 mm. Width of arms, at base 1.2 mm, at the widest part 1.5 mm. Disk circular, slightly concave, rather soft, covered with fine imbricating scales, which are rather obscured, so that the disk appears as though covered by a thick skin. Radial shields very small, short, exceedingly narrow, tapered within, widely separated from each other, hard to detect. Ventral interbrachial areas covered with scales similar to those of the dorsal side, but even more obscure. Genital slits large, nearly reaching disk margin. No genital papillæ.

Oral shields rhomboidal, with obtuse inner angle and rounded lateral and outer angles, nearly as wide as long, except madreporic shield, which is decidedly longer than wide. Adoral shields small, acutely tapered within, where they nearly or hardly meet. Four or five oral papillæ on either side of each jaw, unequal, short, rounded, but the outermost one, which is closely associated with the second oral tentacle pore, has pointed inner end. Four teeth, short, stout, with wide end.

Arms long and very slender, narrowed at base, widest at one-fourth to one-third of arm length. Dorsal arm plates mostly triangular, with obtuse outwardly directed apex, rather small, wider than long, successive plates slightly in contact with each other; quadrangular in the more distal parts. On either side of each dorsal arm plate there occurs a large supplementary plate, which is nearly

semicircular, about one-half as large as the dorsal arm plate, and bounded along the distal border by one or two very insignificant secondary supplementary plates, which, however, are present only for a comparatively short distance near the arm base; two or three first dorsal arm plates and their supplementary plates are smaller than those beyond; supplementary plates smaller outwards as dorsal arm plates become quadrangular, and finally disappear. Lateral arm plates not very prominent, meeting neither above nor below. First ventral arm plate very small, rather pentagonal, longer than wide; those beyond, quadrangular, with rounded outer lateral angles, truncated inner lateral angles and slightly notched outer border, nearly as long as wide, but longer than wide distally. Three arm spines, short, stout, flattened, blunt. One large, oval tentacle scale to each pore. Color in alcohol: grayish yellow; disk reticulated, and arms banded, with dark purplish brown.

Three specimens; Enoshima. Numerous specimens; Arai Beach, Misaki Marine Biological Station.

The arm length varies from six to eight times the disk diameter. In smaller specimens the arm spines are less flattened; and in those smaller than 4 mm. across the disk the secondary supplementary dorsal arm plates are almost invisible.

This species differs from the genotype, *O. dictydisca* H. L. Clark, in the shape of the dorsal arm plates, in the less distinct secondary supplementary dorsal arm plates and in the smaller and more insignificant radial shields. Further, schizogonic reproduction has not been observed in the present species, though I have examined many very small specimens. *O. marktanneri*, as well as the genotype, resembles *Ophionereis dubia* in lacking the genital papillæ, but differs from it chiefly in the presence of the secondary supplementary dorsal arm plates and in the much narrower arms. *O. marktanneri* is by no means near *Ophionereis porrecta* Lyman. I could mention some more differences than those enumerated by Koehler between these two species, but it is not necessary to do so here.

This charmingly handsome species is one of the most common ophiurans about Misaki, living under stones and rocks.

Family 5. **OPHIOCOMIDÆ** Ljungman, 1867.

(Characters as given in keys, pp. 74 and 75.)

Key to subfamilies of Ophiocomidæ.

A—Radial shields long and wide, boot-shaped, widely separated from each other; three to five arm spines; tentacle scales short and leaf-like ..... OPHIOCOMINÆ.

AA—Radial shields long and very narrow, bar-like, each pair approximating each other at the outer ends; numerous arm spines; two tentacle scales, of which the abradial one is minute and acute, and the adradial one is very long and lanceolate,
OPHIOPSILINÆ.

Subfamily 1. OPHIOCOMINÆ nov.

(Characters as given above in key.)

This subfamily includes *Ophiopteris*, *Ophiocoma*, *Ophiomastix* and *Ophiarthrum*.

Subfamily 2. OPHIOPSILINÆ nov.

(Characters as given above in key.)

This subfamily is formed by a single genus, *Ophiopsila*.

Though *Ophiopsila* is referred to the Amphiuridæ by certain authors, it fundamentally differs from the latter in the internal structures. The oral frames have well-developed lateral wings, as in the Amphiuridæ, Ophiotrichidæ, *Ophioceramis*, Ophionereidinæ and Ophiocominæ. The oral and dental plates are π-shaped (instead of being x-shaped) in common outline in internal view, quite as in *Ophioceramis*, the Ophionereidinæ and Ophiocominæ. The genital plates are entirely free from the basal vertebræ and have two condyles and one pit at the outer end to match two condyles and one pit of the radial shield, as an important characteristic of the Chilophiurida; while those of the Amphiuridæ and Ophiotrichidæ are firmly fixed to the basal vertebræ and have only a single large condyle to match one large socket of the radial shield. The genital scales are long, narrow and bar-like, also a characteristic of the Chilophiurida; while those of the Gnathophiurida are short, very flat and leaf-like. As to the external characters, the presence of both oral and well-developed dental papillæ hinders any reference of *Ophiopsila* to either the Amphiuridæ or Ophiotrichidæ. In short, *Ophiopsila* is referable only to the Ophiocomidæ, being, however, distinguished from the other genera of that family by certain characters of secondary importance.